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THE EVALUATION OF SEEDBEDS, METHOD OF SEEDING, AND SPECIES FOR RESEEDING ARID RANGELANDS OF ARIZONA

Pima, Congress, and Fredonia Areas

A Progress Report for the Calendar Year

1966

submitted to

The Bureau of Land Management
United States Department of the Interior

prepared by

The Department of Watershed Management
Agricultural Experiment Station
University of Arizona

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PREFACE

The studies covered in this report were supported under a research contract between the Bureau of Land Management and the Agricultural Experiment Station, University of Arizona. This is a Progress Report submitted to the Bureau in partial fulfillment of that Contract. The material herein should not be used in other manuscripts without the permission of the above agencies. Many of the indications from the results of these studies are tentative and subject to modification from further research. Parts of these studies are also being utilized in the research programs of graduate students.

The cooperation of many persons is acknowledged: the personnel of the Arizona State and District Offices of the Bureau of Land Management have been most helpful and progressive in their actions. The Plant Materials Center, SCS, has aided in seed procurement. Project personnel consisted of Mr. R. Leslie Rawles, Assistant in Research; Mr. Richard Stevens, Graduate Assistant; Mr. Melvin Wilhelm and Mr. Thomas Smith, Graduate Students.

Gilbert L. Jordan,
Project Leader

March 1967

INTRODUCTION

This is a progress report for the calendar year 1966 covering the experimental range-seeding studies conducted near Fredonia, Congress, and Pima, Arizona. At each location several methods of seedbed preparation and shrub control were compared for their effectiveness in establishing various range grasses. On each seedbed the relative effectiveness of different times and methods of seeding was also evaluated. Although the vegetation, climate, and soils varied among the locations, the objectives common to all locations were as follows:

(1) To evaluate seedbed preparations and methods of seeding to more effectively revegetate the range type under study.

(2) To evaluate both chemical and mechanical methods of shrub control.

(3) To select those forage species best adapted to the particular range type.

(4) To determine, by appropriate instrumentation, the microenvironmental conditions limiting the germination, growth, and establishment of grass seedlings.

The previous progress report of 1964 and 1965 has covered in general the geography, legal description, native vegetation, climate, and soils characteristic of each location. Where additional data were obtained, they have been included in this report. The tabulation of the

climatic factors (precipitation, temperature, and relative humidity) was continued for each area in 1966. The importance of the various climatic and edaphic data are discussed in relation to the results from the different seedings. For the Fredonia area, the climatic data were supplemented by readings from an anemometer and an evaporation pan.

Each of the areas were under fence to protect them from grazing by livestock. The seedings were further protected from rodents and rabbits by the use of poisoned salt licks. The control of rabbits by using poisoned salt licks varied from good to poor. At Fredonia, the species adaptation studies were protected by a rabbit-proof fence in addition to the use of poisoned salt.

At each of the areas, species adaptation studies were continued as started in 1964. In these studies, about 20 of those forage species considered to be possibly adapted to the particular area were seeded in a small nursery. Data from these nurseries, consisting of plant counts made in the fall, are presented for the 1964, 1965 and 1966 nurseries.

The main data in this report relate to the evaluation of seedbeds and time and method of seeding. These data consist of the average number of plants per 100 square feet on each seedbed and seeding variable studied. Plant counts have been made on the 1964, 1965 and 1966 seedings at each of the areas during the fall of 1966. From these results, evaluations were made of the previous years' seedings as well as the seedings made in 1966.

Photographic data have been included where applicable. Data were included for the Fredonia area which relate to the degree of competition

from globe mallow and sagebrush on the various seedbeds. A study on the effects from the control of globe mallow was initiated during 1966. Preliminary forage yields from certain seedings at Fredonia and Pima have been included in this years report.

THE CONGRESS AREA

The Congress area was located in west-central Arizona. The exact location of the study site is shown in Figure 1. This is a region of comparatively low rainfall of about 9.5 inches annually, of which about 43% falls during the summer and the remainder falls during the winter. The aridity of this area was reflected by the sparse cover of shrubs consisting mainly of creosotebush, mesquite, and snakeweed. The percentage crown cover and density of plants per acre for the native vegetation was given in both the 1964 and 1965 Progress Reports. The only perennial grass found in the area was tobosa. The results from soil analyses were also given in the 1965 Progress Report.

This section of this report covers the plant counts made in November, 1966 on the seedings made in 1964, 1965 and 1966 at Congress. These counts consisted of the number of plants in 20 randomly-placed quadrats in each plot. The quadrat size was 1 by 5 feet. It is appropriate at this time to review the results of the plant counts taken in 1964 and 1965 and compare them with the plant count taken this year, 1966.

1964 Seeding

A comparison of plant counts made in 1964, 1965, and 1966 for the seeding made in 1964 is shown in Table 1. This comparison reveals that the general increase in number of plants from 1964 to 1965 has been

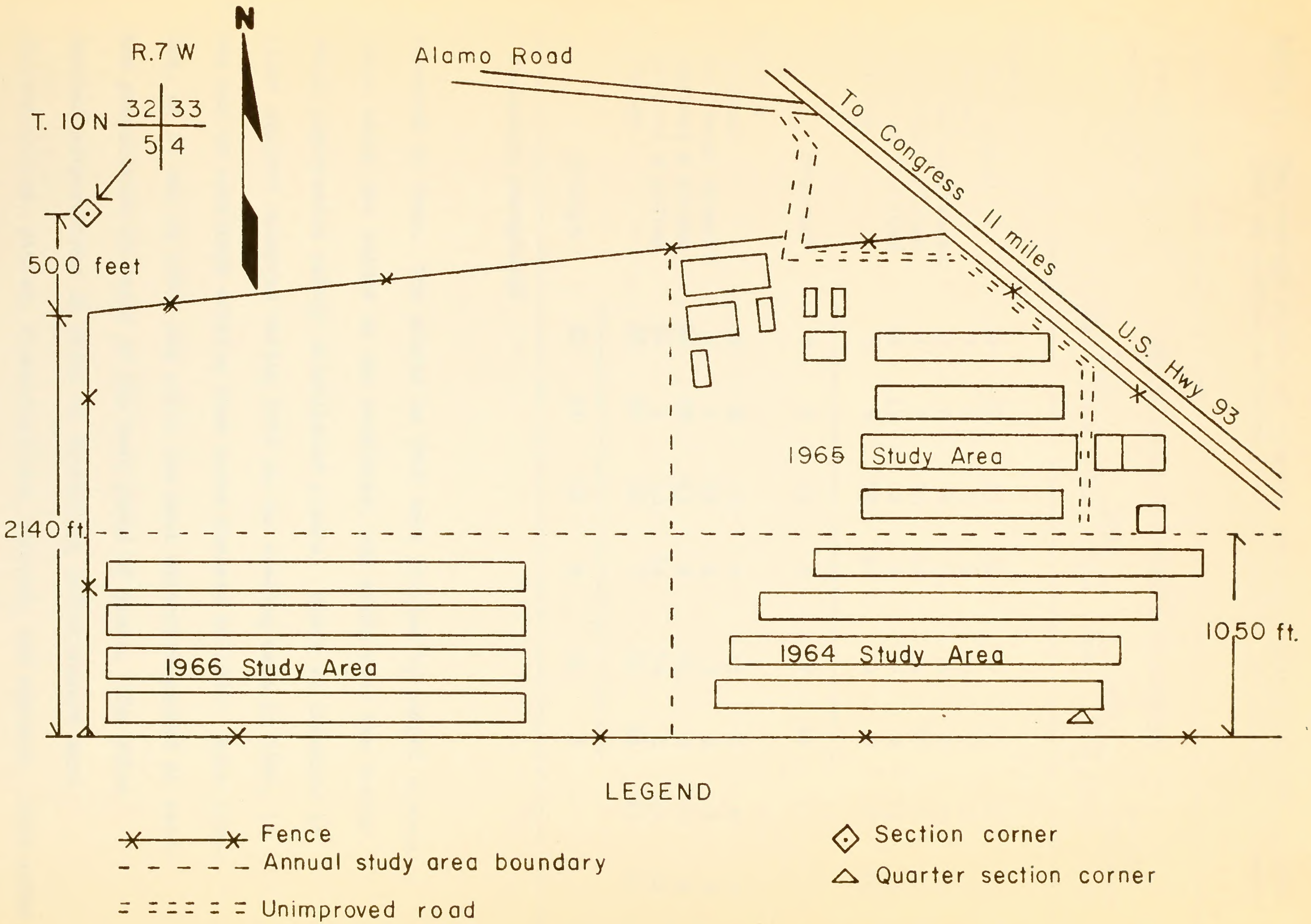

Figure 1. A diagram of the location of the range seeding studies near Congress, Arizona.

Table 1. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1964 at Congress, Arizona.

Seedbed and seeding method	Year of count and season of seeding						Annual averages		
	1964		1965		1966				
	Mar.	June	Mar.	June	Mar.	June	1964	1965	1966
Broadcast									
Root-plowed	18	22	23	59	37	33	20	41	35
Chained	0	0	0	0	0	0	0	0	0
Bulldozer-cleared	0	0	0	0	0	0	0	0	0
Chained & pitted	1	5	44	13	24	57	3	28	41
Cleared & pitted	14	13	4	6	2	4	13	5	3
Pitted	9	8	28	12	14	8	9	20	11
Average*	5	5	15	6	8	14			
Drilled									
Chained	0	0	8	0	2	0	0	4	1
Bulldozer cleared	4	1	13	6	3	0	2	9	1
Chained & pitted	29	18	15	4	22	3	23	9	12
Cleared & pitted	22	1	13	11	14	6	11	12	10
Pitted	60	50	23	7	40	14	55	15	27
Average	23	14	14	5	16	5			

* Excluding rootplowed

reversed in 1966. The plants in 1966 were counted by height classes - those under two inches or new seedlings, and those over two inches which represented mainly established plants. Where an increase in plant numbers occurred during 1966 on the seeding made in 1964, it was due to seedlings arising from seeds planted in 1964. Root plowing, as it was in 1965, was still the most effective method of seedbed preparation in terms of the best stand of grass. The other seedbed preparations in order of decreasing effectiveness were chained-pitted, pitted, cleared-pitted, cleared, and chained. This order

was the same as it was in the 1965 count. Only the chained-pitted and certain pitted plots showed an increase in plant numbers over the preceding year. All other seedbed preparations showed a small decrease in plant numbers.

With respect to time and method of seeding during 1964, drilling in March remained, as in both the 1964 and 1965 counts, more effective than drilling in June. In fact, drilling in June gave the poorest response. There was, in 1966, no particular difference between the March and June broadcasting. Broadcasting was generally as effective as drilling. Some degree of soil disturbance was indicated as being necessary for more successful range seeding in the Congress Area as evidenced by the response from the pitted and root plowed areas. Even so, the best stand, obtained on the root plowed seedbed, was deemed poor in terms of economical forage production.

1965 Seeding

The plant count in November of 1965 on the 1965 seeding depicted a large number of mainly small seedlings. Due to good winter moisture, over 7 inches of rain in November and December of 1965, there was a very good growth of spring annuals, mostly filaree. After December 1965 there was very little precipitation, only 0.44 inch* from January 1, 1966 until August 9, 1966. Very little moisture was available in the early part of the Lehmann lovegrass growing season. The number of plants counted in November of 1966 on the 1965 seeding was only 3% of the number counted in 1965. Of those plants counted in 1966, about 10% were new seedlings.

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* The rain guage out of order from 1-6-66 to 2-18-66.

was the same as it was in the 1965 crops. Only the chemically-plowed and certain plowed plots showed an increase in plant numbers over the previous year. All other seedbed preparations showed a small decrease in plant numbers.

With respect to time and method of seeding during 1966, drilling in March resulted, as in both the 1964 and 1965 records, more effective than drilling in June. In fact, drilling in June gave the poorest response. There was, in 1966, no particular difference between the March and June broadcasting. Broadcasting was generally as effective as drilling. Some degree of soil disturbance was indicated as being necessary for more successful range seeding in the Longview Area as evidenced by the response from the plowed and non plowed areas. Even so, the best stands obtained on the non plowed seedbed, the second year is [illegible] of [illegible] lack through production.

1966 Seedings

The plant count in November of 1965 on the 1965 seeding indicated a large number of mainly small seedlings. Due to good winter moisture, over 3 inches of rain in November and December of 1965, there was a good growth of spring annuals, mainly filaree. After December 1965 there was very little precipitation, only 0.44 inch* from January 1, 1966 until August 8, 1966. Very little moisture was available in the early part of the 1966 growing season. The number of plants counted in November of 1966 on the 1965 seeding was only 9% of the number counted in 1965. Of those plants counted in 1966, about 1[illegible] were new seedlings.

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* The rain gauge was out of order from 1-1-66 to 8-10-66.

This indicates a very high mortality in the 1965 seeding during the early summer of 1966. The pitted plots had over a 98% reduction of the 1965 count. The results from both the 1965 and the 1966 counts are presented in Table 2. From the standpoint of the number of plants present in 1966, the cleared-pitted seedbed was the most effective, followed by the root plowed, the chained-pitted and the pitted seedbeds. The pronounced differences due to time and method of seeding in 1965 were no longer evident from the 1966 plant count. However, the relative differences still persist with drilling in March giving somewhat better results, followed by June-broadcast, the June-drilled and the March-broadcast. However, even the best stands of grass were poor in terms of forage production. The extensive reduction in the 1965 stand illustrates the aridity often incurred during the summers at the Congress site.

Table 2. The average number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1965 and counted in 1965 and 1966 near Congress, Arizona.

Seedbeds	Time and method of seeding								Average	
	Broadcast				Drilled					
	1965		1966		1965		1966			
	March	June	March	June	March	June	March	June	1965	1966
Rootplowed	27	507	7.2	13.2	-	-	-	-	262	10.3
Pitted-	31	441	1.5	1.2	238	223	5.0	4.0	233	2.9
Chained-Pitted	46	603	5.0	7.0	477	245	17.2	9.2	343	9.6
Cleared-Pitted	186	448	5.25	19.7	643	318	19.5	12.7	398	14.3
Average (Excluding rootplowed)	87	497	3.8	7.3	452	263	13.9	8.7		

1966 Seeding

The major factors of range seeding that were studied in 1966 are as follows:

(1) A comparison of root plowing, chaining, chaining-pitting, bulldozer clearing, clearing-pitting, and chaining-disking and clearing-disking as methods of seedbed preparation and/or brush removal.

(2) March vs. June as a comparison of time of seedbed preparation and seeding.

(3) Broadcasting vs. drilling as methods of seeding.

The experimental design was a randomized-block with four replications. The plot size was 100 by 200 feet. The combinations of the various factors of seeding are shown in the plot diagram in Figure 2.

The pitting was done with a cut-a-way pitting disk. The clearing operation consisted of clearing all vegetation from the plots with a bulldozer blade. The chaining was accomplished by dragging an anchor chain across the plots in one direction and then in the opposite direction. The root plowing was done with conventional root plowing equipment. The disking was done with a small, farm disk. A Cyclone Seeder was used for broadcasting and a Nisbet Drill was used for drilling.

At the time of the March seedbed preparation and seeding there was a dense stand of annual forbs and grasses. This stand consisted mainly of filaree (_Erodium cicutarium_). The soil during March was moist and during June it was extremely dry as it was normally at that time. On a dry weight basis the average soil moisture during March was 6.6%, 2-inch depth; 9.2%, 6-inch depth; 11.0%, 12-inch depth; and 13.8% at the 18-inch

Rep IV

Rp B M 55	Chd D J 56	Chp D J 57	Chd B M 58	Chp B J 59	Bcd B M 60	Bcp B M 61	Bcp B J 62	Chp B M 63	Chp D M 64	Bcd B J 65	NT	Chd D M 66	Rp B J 67	Chd B J 68	NT	NT	Bcd D M 69	Bcp D M 70	Bcd D J 71	Bcp D J 72

Rep III

Bcp B M 37	Chd D M 38	Chp B J 39	Chp D J 40	Rp B M 41	Bcp D M 42	Bcp D J 43	Rp B J 44	Bcd B J 45	Bcd D M 46	NT	NT	Bcd D J 47	Chp D M 48	Chd B J 49	NT	Bcp B J 50	Chd B M 51	Chd D J 52	Bcd B M 53	Chp B M 54

Rep II

Bcp B J 19	Chp B M 20	Bcp B M 21	Rp B M 22	NT	Chd D J 23	Chd B M 24	Rp B J 25	Chp D M 26	Chp B J 27	NT	Chp D J 28	Bcp D M 29	Chd D M 30	Bcd B M 31	NT	Chd B J 32	Bcp D J 33	Bcd D J 34	Bcd B J 35	Bcd D M 36

Rep I

Rp B J 1	Bcp B J 2	NT	Chp D J 3	Chd B J 4	Bcd D J 5	Chp B J 6	Bcd B J 7	Bcp D M 8	Bcp D J 9	Chd D M 10	Chd D J 11	Chp D M 12	Bcp B M 13	NT	Chd B M 14	Bcd B M 15	Rp B M 16	Bcd D M 17	Chp B M 18	Species

LEGEND

Rp	rootplowed	Bcd	bulldozer cleared & disked	M	March
p	pitted	Chd	chained & disked	J	June
Bcp	bulldozer cleared & pitted	B	broadcast	NT	not treated
Chp	chained & pitted	D	drilled		

Plot size: 100 by 200 feet

Figure 2. A plot diagram of the time and method of seeding on various seedbeds on rangelands near Congress, Arizona during 1966.

depth. Both the March and the June seedings were made with Lehmann lovegrass at the rate of 1/2 pound of seed per acre.

The 1966 seeding studies were similar to those of the two preceding years, except that the pitted-only treatments were omitted and disking was added. Plant counts were made in November of 1966. Most of the plants at this time were small, under two inches in height, with a few plants 6 to 8 inches in height and headed out. The results of the count are shown on Table 3.

Table 3. The average number of Lehmann lovegrass per 100 square feet on various seedbeds planted in 1966 and counted in 1966 at Congress, Arizona.

Seedbed	Time and method of seeding				Average
	Broadcast		Drilled		
	March	June	March	June	
Rootplowed	298	358	-	-	328
Chained-pitted	270	184	143	88	171
Cleared-pitted	82	150	87	51	93
Chained-disked	214	90	152	101	139
Cleared-disked	172	185	104	79	135
Average (excluding rootplowed)	184	152	123	80	

Only a limited evaluation can be made on this seeding at this time. With respect to the time and method of seeding, again drilling in March was more effective than drilling in June. However, broadcasting in March was better than broadcasting in June which was a reversal of the results obtained in 1964 and 1965. Both of the broadcast treatments were more effective than the drilled treatments, which was again the opposite of the results from the 1964 and 1965 seedings. With respect to the different seedbed treatments, the root plowed was again most effective followed, in order of decreasing effectiveness, by the chained-pitted, the chained-disked, the cleared-disked, and the cleared-pitted, It was found that most of the larger plants had developed seed heads and were found in root plowed March-broadcast plots. It was also noted that while the root-plowed plots had the largest number of plants and almost all of the larger plants, they also had many of the smallest plants counted. The plants found in the 1966 seeding in comparison with those found in the first season of 1965 seeding, while not as many in number, were for the most part a little larger and more vigorous.

On the basis of the results from the 1964 and 1965 seedings, it is expected that a reduction in stand will occur by the end of the next growing season. The reason for the disked seedbed treatments in this year's study was for comparison with the pitted treatments. Specifically, the comparison was to determine how much of the response from pitting was due to soil disturbance rather than from the effect of pits. It can be noted from Table 3 that disking was similar in effects to pitting which indicates that soil tillage and not pitting was a major factor in promoting

seedling growth. Final evaluation cannot be made, however, until one or two growing seasons have elapsed because the pits might be the more important factor in maintenance of the stand.

As in the past years, the results from any particular experimental seeding are, in part, interpreted in terms of the weather during the growing season.[1] From July 1 through October 4, 83.3 mm. of rain fell (3.28 inches). Of this amount, only 31.7 mm (1.25 inches) was calculated to be effective moisture available for germination and seedling growth. A comparison between total precipitation and effective moisture is graphically presented in Figure 3. This comparison indicates that the moisture effective for germination and seedling growth occurred mainly during one period of four days near the middle of September. Observations during the growing season support the above conclusion based on the amount of effective moisture. There was no emergence of Lehmann lovegrass from the precipitation that occurred in mid-August.

Species Adaptation Studies

In July of 1965 a special seeding was made to test two new strains, one of Lehmann lovegrass (Apache), and one of Boer lovegrass (Catalina). These experimental strains were developed by the ARS. These two new strains were broadcast on both cleared and cleared-pitted seedbeds along with commercial strains of Lehmann lovegrass and Boer lovegrass. A plant count was made in November, 1966. While only a few plants of either strain of Lehmann lovegrass were found, a considerable number of plants of the two strains of Boer lovegrass were found (Table 4). As might be

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[1] See the 1964 and 1965 Progress Reports.

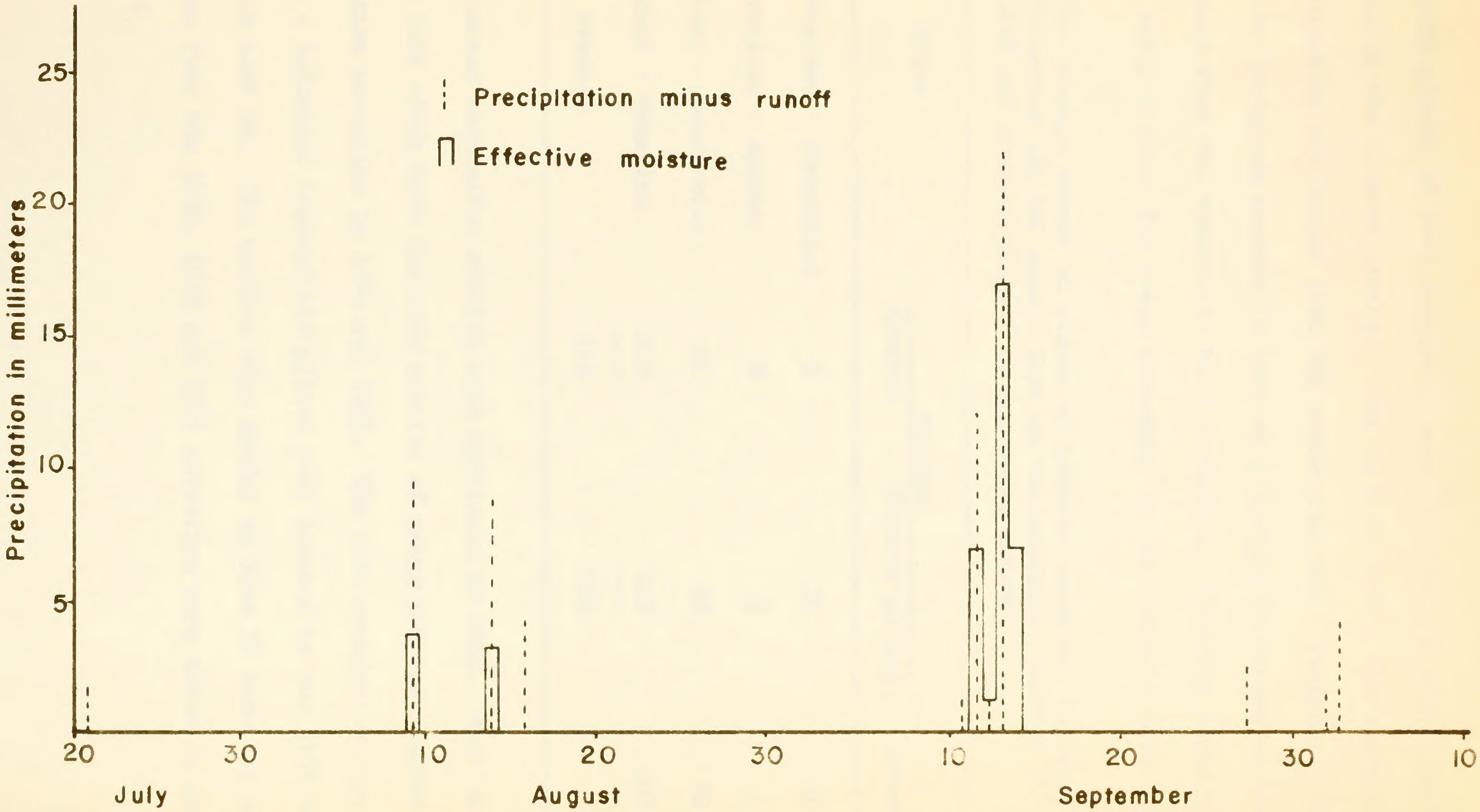


Figure 3. A comparison between the precipitation and the resultant effective moisture for plant growth during the summer of 1966 at Congress, Arizona.

expected, more plants of Boer lovegrass were found on the cleared-pitted seedbed than on the cleared seedbed. But in both cases, the number of plants of Catalina was larger than the commercial Boer lovegrass. The Catalina-Boer lovegrass appears to have more drought hardiness in the seedling stage than the commercial Boer lovegrass. Catalina shows some promise of being adapted for range reseeding in the Congress area.

Table 4. The average number of plants of Lehmann lovegrass and Boer lovegrass per 100 square feet on two seedbeds, planted in 1965 and counted in 1966 at Congress, Arizona.

Grass	Seedbed		Average
	Cleared	Cleared-pitted	
Lehmann lovegrass - Commercial	0	20	10
Lehmann lovegrass - Apache	0	0	0
Boer lovegrass - Commercial	96	88	92
Boer lovegrass - Catalina	136	268	202
Average	116	188	

The species adaptation studies were continued in 1966. Most of the species in this study were the same species of range grasses planted in the adaptation nurseries in 1964 and 1965. The 1966 species nursery was planted in a bulldozer cleared and pitted plot located in the 1966 seeding area next to plot 18. The species were seeded on June 10 into dry soil. Plant counts from the 1964, 1965 and 1966 nurseries were taken in November of 1966.

In the 1966 species nursery, Lehmann lovegrass was seeded to obtain a direct comparison with the other species. Several of the species gave a good response. The best response was given by the Catalina strain of Boer lovegrass, followed by Lehmann lovegrass, the Apache strain of Lehmann lovegrass and the standard Boer lovegrass (Table 5). Several other species, sand dropseed, Turkestan bluestem, and Wilman lovegrass gave a response that would be adequate for the normal moisture conditions if the present numbers could be maintained.

Table 5. The number of plants per 100 square feet in the species adaptation nursery planted at Congress, Arizona in 1966. Plants counted in November, 1966.

Plot No.	Species	Common name and source		No. of plants
1	Erle	Lehmann lovegrass	A-68	200
2	Erle	Lehmann lovegrass	61-280-19ARS	164
3	Erch	Boer lovegrass	A-84	70
4	Erch	Boer lovegrass	61-293-17ARS	238
5	Spco	Spike dropseed	A-14544	4
6	Spcr	Sand dropseed	A-16352	44
7	Ersu	Wilman lovegrass	A-11965	36
8	Anis	Turkestan bluestem	A-14207	39
9	Paco	Pretoria panicgrass	A-12638-M63	10
10	Paco	Pretoria panicgrass	A-12638	4
11	Paan	Blue panicgrass	A-16851	6
12	Paan	Blue panicgrass	A-130	4
13	Trca	Arizona cottontop	A-8084	0
14	Paob	Vine mesquite	A-11171	1
15	Boer	Black grama	A-3730	10

The response of the 1965 nursery was poor and the count in November 1966 showed no response from any of these species. Very poor emergence resulted in 1964 nursery, but a few plants were present in 1965. In the count made in November 1966, all but three of the nineteen species gave some response. The best response was shown by sideoats grama, followed in order of decreasing numbers by creeping dropseed, blue grama (which had the best response in 1965 count) and Turkestan bluestem as shown in Table 6. The response of these species in each year's nursery, will be followed in forthcoming years relative to their adaptation to this range area. In particular, Catalina Boer lovegrass will receive extensive testing.

Table 6. The approximate number of plants per 50 square feet in the species adaptation nursery at Congress. Planted in 1964 and counted November 1965 and November 1966.

Plot No.	Species	Common name and source	No. of Plants 1965	No. of Plants 1966
1	Boer	Black grama	0	0
2	Bogr	Blue grama	24	7
3	Bohi	Hairy grama	0	1
4	Anis	Turkestan bluestem	0	6
5	Trca	Arizona cottontop	9	0
6	Sema	Plains bristlegrass	3	1
7	Mupo	Bush muhly	0	1
8	Erch	Boer lovegrass	0	4
9	Ersu	Wilman lovegrass	0	4
10	Erin	Plains lovegrass	0	2
11	Bocu	Sideoats grama	0	24
12	Spcr	Sand dropseed	0	9
13	Spus	Creeping dropseed	3	12
14	Spco	Spike dropseed	6	3
15	Paco	Pretoria panicgrass	0	3
16	Paan	Blue panicgrass	6	0
17	Paob	Vine mesquite	0	5
18	Paha	Hall's panicgrass	0	4

THE PIMA AREA

This area lies at an elevation of 3,100 feet in an area locally known as Mesquite Wells, northwest of Pima, Arizona. The exact location of the range seeding studies in this area is depicted in Figure 4. A general description of the area was given in the 1964 Progress Report. A survey of the native vegetation was presented in the 1965 Progress Report and the results of a soil analysis were reported in the 1965 Progress Report. The progress of the 1964 and 1965 seedings and the nature and results from the 1966 seeding will be presented in the following discussion.

The 1964, 1965 and 1966 seedings were observed throughout the summer growing season. Plant counts on all seedings were made in November. The data from these counts will be presented in the same fashion as was used for the Congress area to facilitate comparisons between these two range sites for the three years. In addition to the plant count data, in March 1966 an estimate of forage weight was made on the 1964 seeding and in November 1966, grass clippings and weights were taken on the 1964 and 1965 seedings. These data will also be presented in this report.

1964 Seeding

The fourth replication and the south half of the third replication of the 1964 seeding were fenced in February of 1966. This amounted to

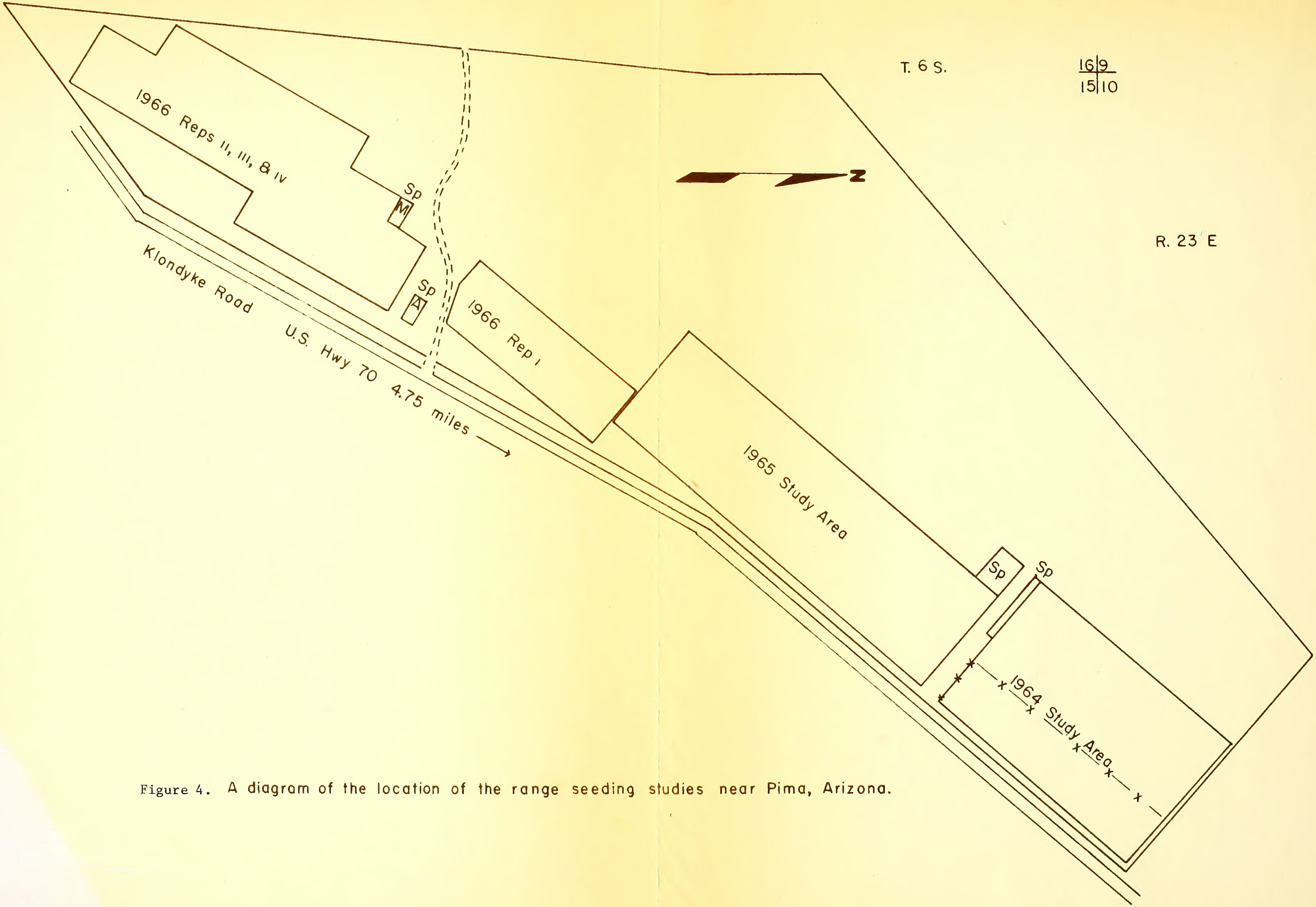


Figure 4. A diagram of the location of the range seeding studies near Pima, Arizona.

17.4 acres. On March 5, 1966, 20 head of cattle were turned into this fenced area and left there for several days for observation. An estimate of the air-dry forage on these plots was 1650 pounds. This forage was from Lehmann lovegrass which was almost entirely dormant at this time of the year. No supplements were given and the water was hauled. The purpose of this study was to gain an initial insight of the response of cattle utilizing Lehmann lovegrass at this time of the year.

The full weight on water of the various types of cattle were as follows:

3 cows	2360 pounds
4 "	2850 "
4 "	2785 "
2 "	1770 "
1 heifer (2 yr.old)	505 "
1 heifer "	635 "
1 steer "	715 "
1 bull (1. yearling)	690 "
1 steer "	840 "
2 steers (yearling)	990
1 calf	
20 cattle	14,140 pounds

The final weights and length of time the cattle were on these plots was not available at the time of this report. The final comments, however, were that these cattle lost weight and that Lehmann lovegrass at this time of the year without supplemental feed was of low forage value.

The results of the 1966 count on the 1964 seeding along with a review of the 1964 and 1965 counts are given in Table 7. From 1964 through 1965 the stand of grass increased on all seedbeds and methods of seeding to about double the original stand in 1964. Excepting for the more dense stands, there was also a smaller general increase in plant numbers during 1966. In the initial seeding, drilling in March was markedly superior to drilling in June or broadcasting in either March or June. Broadcasting in June produced better initial stands than broadcasting in March. By 1966, however, there was little or no practical difference between the two seeding methods or times of seeding due to the consistant steady improvement of all stands. The density of the several stands appears to be approaching a plateau of about one plant per square foot. The bulldozer cleared, and chained plots which were broadcast seeded were the least productive treatments. All of the drilled plots and the pitted or rootplowed plots have attained a satisfactory stand density. This response is in sharp contract to the opposite response obtained at the Congress Area.

It is believed that this increase in stands came from seed of plants that matured in 1965. Of particular interest is the larger increase in seedlings on the grazed plots. The percentage of new plants (seedlings) on the grazed area was 63.7% in contrast to 39% in the non-grazed area. In terms of total plant numbers, the grazed area had an average of 117 plants per 100 square feet while the non-grazed area had 68. Suggested reasons for the increase on the grazed area are: (1) increased germination of seed trampled into the soil, and (2) reduction of competition for the new seedlings by removal of some of the older plants.

Table 7. The average number of Lehmann plants per 100 square feet on different seedbeds planted in 1964 at Pima, Arizona.

Seedbed and seeding method	Year of count and time of seeding						Annual Average		
	1964		1965		1966				
	Mar.	June	Mar.	June	Mar.	June	1964	1965	1966
Broadcast									
Chained & pitted	17	72	59	123	51	127	44	91	89
Cleared & pitted	16	67	31	81	78	115	41	56	96
Rootplowed	24	47	67	129	103	104	35	98	103
Bulldozer cleared	7	17	22	34	45	60	12	28	57
Chained	12	25	23	66	41	98	18	45	69
Average	15	45	34	76	54	100			
Drilled									
Chained & pitted	139	26	230	97	110	80	82	163	95
Cleared & pitted	68	46	148	95	129	98	57	121	113
Bulldozer cleared	47	31	105	75	82	86	39	90	84
Chained	44	15	116	44	70	77	35	80	73
Average	75	30	150	78	98	85			

To more adequately characterize the stands on the 1964 seeding, forage weights were determined in late November on each of the seedbeds. A strip 200 feet long diagonally across each plot was harvested with a 20-inch rotary mower. The clippings were caught in a bag and subsequently dried at 70°C and weighed. The grass was cut at the 1 1/2-inch height. It was found that this method of harvesting underestimated forage production on the more productive plots because it was difficult to catch all of the forage in the bag. Subsequently, clippings were made from 10,

1 by 5-foot quadrats on each plot. The forage was oven dried and the results are presented in Table 8.

Drilling in March and broadcasting in June were the best combinations of method and time of seeding for forage production. The root plowed and pitted seedbeds generally produced more forage than the chained or cleared treatments.

Table 8. A comparison of the number of plants per 100 square feet with pounds per acre on various seedbeds seeded in 1964 at Pima, Arizona.

Seedbed and seeding method	Time of seeding and yield			
	March		June	
	Number of plants	Pounds per acre	Number of plants	Pounds per acre
Broadcast				
Chained & pitted	51	215	127	371
Cleared & pitted	78	211	115	337
Rootplowed	103	485	104	740
Bulldozer cleared	45	243	60	220
Chained	41	4	98	54
Average	54	168	100	246
Drilled				
Chained & pitted	110	317	80	165
Cleared & pitted	129	417	98	143
Bulldozer cleared	82	187	86	193
Chained	70	66	77	109
Average	98	247	85	152

1965 Seeding

The 1965 seeding was counted in November 1966 and results are compared to those obtained in 1965 (Table 9). In comparison with the 1964 seeding where all treatments increased in plant numbers the second year, the 1965 seedings in all treatments decreased in plant numbers during the second year. Although some of the individual plots that had relatively small numbers of plants in 1965 did gain in numbers, this did not compensate for the decrease in number of plants by those plots which had the larger counts in 1965. The results from the harvesting of forage from the 1965 seeding are also included in Table 9.

Table 9. The yield of Lehmann lovegrass in pounds per acre and number of plants per 100 square feet on various seedbeds planted in 1965 at Pima, Arizona.

Seedbed and seeding method	Year of count and time of seeding						Average	
	1965		1966		1966			
	March	June	March	June	March	June	No.	lbs.
	Plants per 100 sq. ft.				lbs. per acre			
Broadcast								
Chained & pitted	44	4	64	14	880	1	34	440
Cleared & pitted	201	6	73	16	1167	59	44	613
Rootplowed	276	79	88	43	340	575	65	407
Bulldozer cleared	259	5	87	11	234	16	49	125
Chained	71	3	52	11	237	1	31	119
Average	143	4	69	13	630	19		
Drilled								
Chained & pitted	81	52	55	29	304	131	42	217
Cleared & pitted	73	31	64	35	778	50	50	414
Bulldozer cleared	73	18	44	24	48	32	34	40
Chained	34	11	17	13	69	5	15	37
Average	65	28	65	45	300	55		

There were many mature plants in the 1965 seeding in the fall of 1965 but no new seedlings were found in November 1966. Of the times and methods of seeding, seeding in March was particularly effective for both drilling and broadcasting with regard to stand density and yield per acre. Drilling in June was slightly more effective than broadcasting in June.

The response of the various seedbeds from broadcast seedings in order of decreasing stand densities was as follows: Root plowed, cleared, cleared-pitted, chained-pitted, and chained. However, with respect to forage production, root plowed, chained-pitted, and cleared-pitted were markedly better than the non-pitted plots. This order also holds for both stand density and forage production on those seedbeds that were drill seeded.

The data from harvesting the 1964 and 1965 seedings indicate that plant counts do not always accurately reflect the amount of forage produced. The number of plants may apparently decrease from one year to the next, but this may be due to the difficulty in distinguishing individual plants as the stand matures. This agrees with the observations that the plants on the cleared or chained plots were stunted in contrast with those on the root plowed or pitted plots. Forage yields from the Pima area have been much higher than from the Congress Area.

The March drilled plots consistantly produced better yields than the June drilled; but with broadcasting, the results are not consistant with respect to time of seeding. The yield of the five seedbed treatments was not consistent from the 1964 seeding to the 1965 seeding, and did not always follow the same order as the plant count. The data indi-

cated that some method of soil disturbance was necessary for a good yield of grass. The chained and the bulldozer cleared plots most often had the smaller plant numbers and much lower yields.

1966 Seeding

The following major factors of range seeding were studied during 1966 at the Pima area.

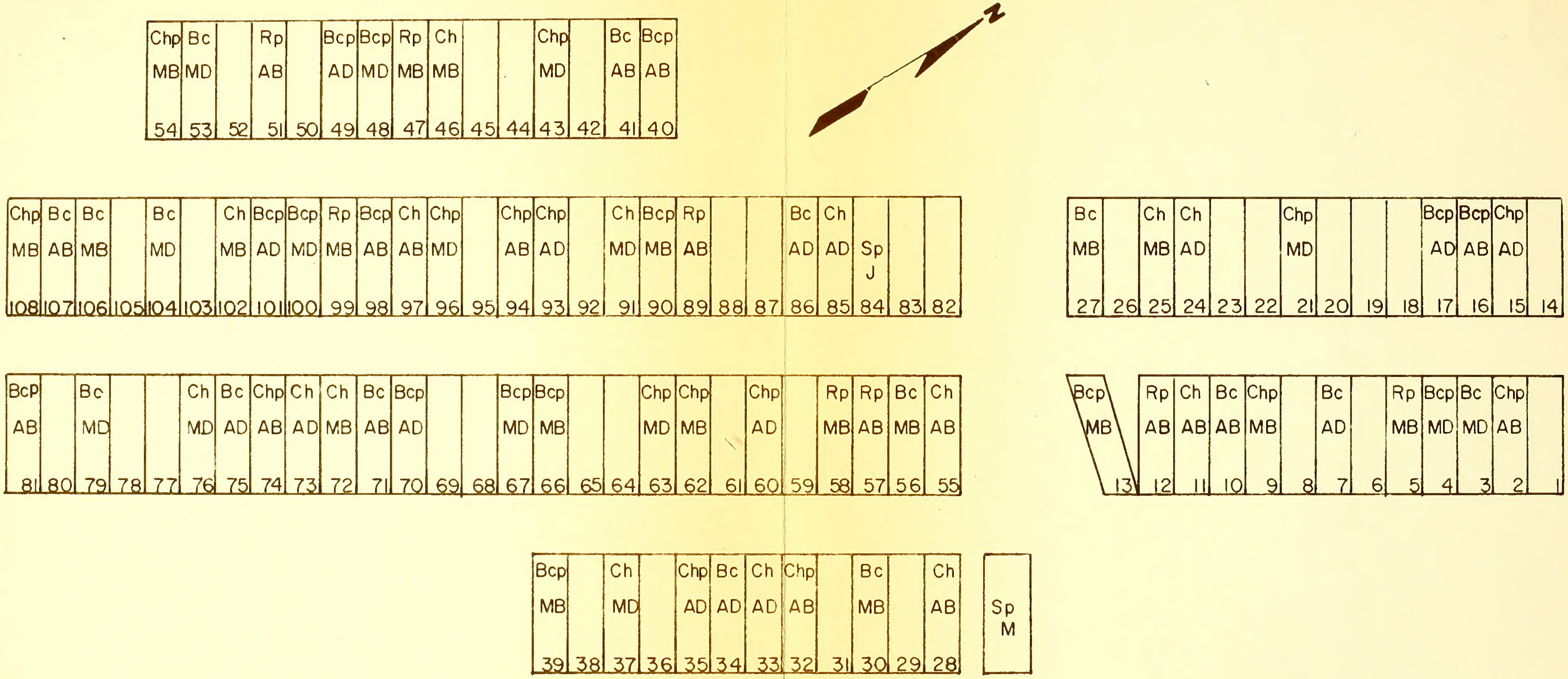
(1) A comparison of root plowing, bulldozer clearing and pitting, chaining, and chaining and pitting as methods of brush removal and seedbed preparation.

(2) March vs. April were compared for times of seedbed preparation and seeding.

(3) Broadcasting was compared with drilling as a method of seeding on various seedbeds.

All combinations of the above factors were combined in a randomized block experimental design having four replications. The plot size was 100 feet by 200 feet. A plot diagram is presented in Figure 5.

The bulldozer clearing treatment consisted of removing all vegetation from the surface of the soil with a bulldozer blade. The chaining was conducted by dragging a heavy anchor chain, hooked between two crawler tractors, in first one direction and then in the opposite direction across each plot. The root plowing was done with standard root plow equipment. The pitting was super-imposed on some of the chained and cleared treatments and was performed by a custom-made, cut-a-way pitting disk. All seedings were made with Lehmann lovegrass at the rate of 1/2 pound per acre. Drilling was accomplished with a modified Rangeland Drill, and broadcasting was done with a Cyclone hand seeder.



Chp	Bc		Rp		Bcp	Bcp	Rp	Ch			Chp		Bc	Bcp
MB	MD		AB		AD	MD	MB	MB			MD		AB	AB
54	53	52	51	50	49	48	47	46	45	44	43	42	41	40

Chp	Bc	Bc		Bc		Ch	Bcp	Bcp	Rp	Bcp	Ch	Chp		Chp	Chp		Ch	Bcp	Rp			Bc	Ch	Sp		
MB	AB	MB		MD		MB	AD	MD	MB	AB	AB	MD		AB	AD		MD	MB	AB			AD	AD	J		
108	107	106	105	104	103	102	101	100	99	98	97	96	95	94	93	92	91	90	89	88	87	86	85	84	83	82

Bc		Ch	Ch			Chp				Bcp	Bcp	Chp	
MB		MB	AD			MD				AD	AB	AD	
27	26	25	24	23	22	21	20	19	18	17	16	15	14

Bcp		Bc			Ch	Bc	Chp	Ch	Ch	Bc	Bcp			Bcp	Bcp			Chp	Chp		Chp		Rp	Rp	Bc	Ch
AB		MD			MD	AD	AB	AD	MB	AB	AD			MD	MB			MD	MB		AD		MB	AB	MB	AB
81	80	79	78	77	76	75	74	73	72	71	70	69	68	67	66	65	64	63	62	61	60	59	58	57	56	55

Bcp	Rp	Ch	Bc	Chp		Bc		Rp	Bcp	Bc	Chp	
MB	AB	AB	AB	MB		AD		MB	MD	MD	AB	
13	12	11	10	9	8	7	6	5	4	3	2	1

Bcp		Ch		Chp	Bc	Ch	Chp		Bc		Ch	Sp
MB		MD		AD	AD	AD	AB		MB		AB	M
39	38	37	36	35	34	33	32	31	30	29	28	

LEGEND

Rp	rootplowed	Bcp	bulldozer cleared & pitted	Sp species adaptation studies
Ch	chained	A	April	Plot size: 100 by 200 feet
Chp	chained & pitted	J	June	
Bc	bulldozer cleared			

Figure 5. A plot diagram of the time and method of seeding on various seedbeds on rangelands near Pima, Arizona during 1966.

During the March period of operation, the soil was sufficiently moist for good tillage conditions. At the time of the March seeding, March 26, the soil moisture was 3.6% in the top two inches of soil and averaged 6.9% to a depth of 18 inches. When the April seeding was made on April 15, the soil moisture in the top two inches of soil had dropped to 2.6% and the average to a depth of 18 inches dropped to 4.7%. The soil moisture depletion during this time is depicted in Figure 6. The soil moisture at the 2-inch depth was below the wilting point during both dates of seeding.

In the 1966 seeding the same seedbeds and methods of seeding of the previous two years were repeated but the time of the later seeding was moved from June to April. A June seeding had been planned but did not materialize due to a shortage of equipment. There were three weeks between seedings. This time difference made very little difference in the results from drilling, with the early date having the better stand as in previous years (Table 10). But with broadcasting this short length of time gave a consistant and large increase in number of plants in favor of the later seeding. No particular reason for these results is apparent at this time. However, surface soil temperatures, the presence of pathogenic fungi, and the relative amount of soil moisture are factors suspected as controlling this type of response. The cleared-pitted seedbed treatment gave the largest number of plants followed by chained-pitted, root plowed, bulldozer cleared, and chained in order of decreasing numbers. As in previous years, the disturbed soil seedbeds gave the better stands although no one treatment is consistently the best from seeding to seeding or year to year.

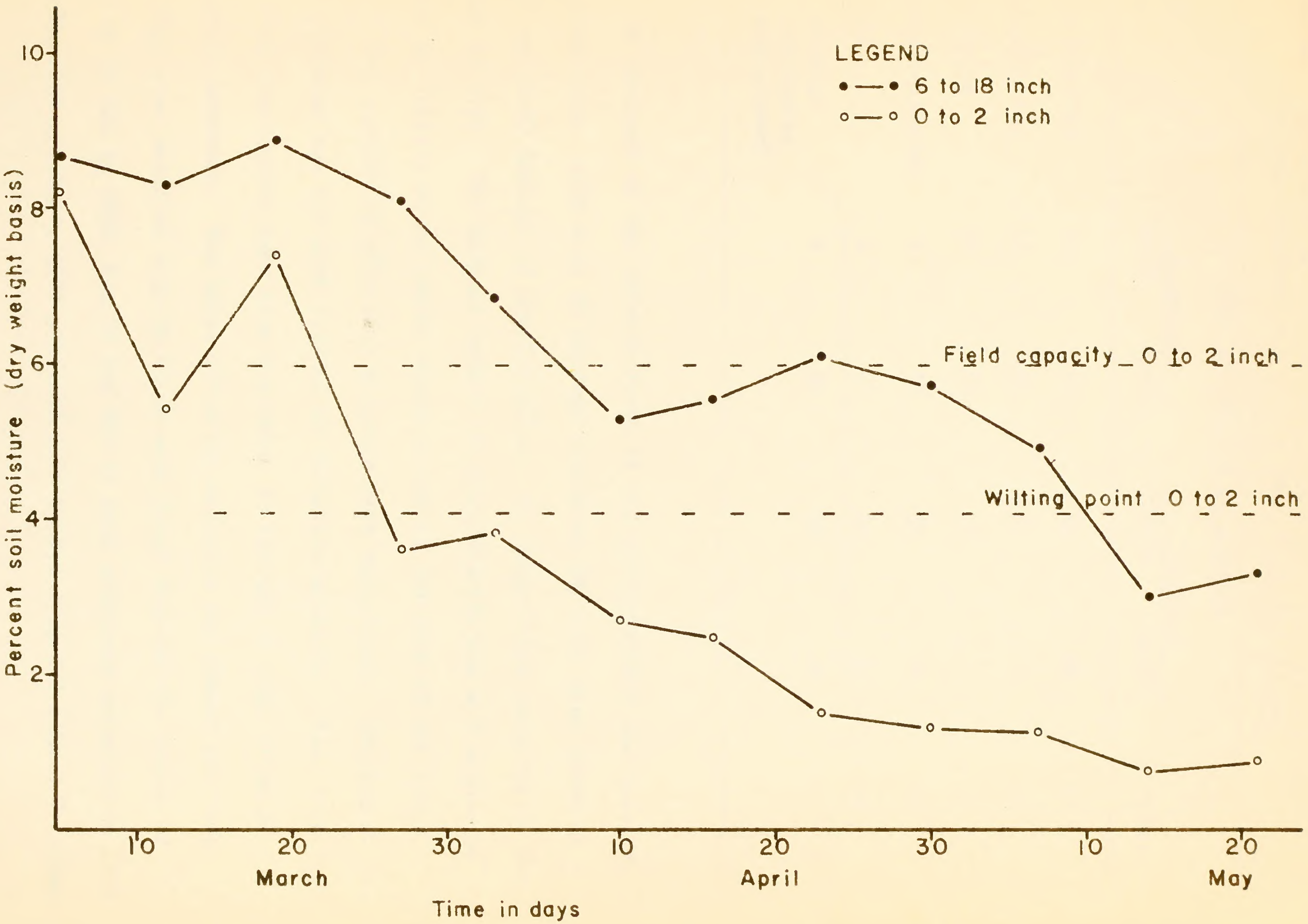


Figure 6. The relationship of soil moisture loss to different dates on the range seeding site at Pima, Arizona in 1966.

Table 10. The number of Lehmann lovegrass plants per 100 square feet on various seedbeds planted in 1966 at Pima, Arizona

Seedbed	Time and method of seeding				
	Broadcast		Drilled		
	March	April	March	April	Average
Chained-pitted	16	76	43	44	45
Cleared-pitted	13	91	81	80	66
Root plowed	27	59	-	-	43
Bulldozer-cleared	5	49	59	45	40
Chained	3	19	24	25	18
Average (excluding rootplowed)	9	59	52	49	

An analysis of the effectiveness of the precipitation was made for the Pima area. From July 19 through September 24, this area received 64.77 mm (2.53 inches) of precipitation. No large rains occurred in the summer of 1966. The largest amount of precipitation was 0.5 inches on August 3. Little or no runoff occurred due to the lack of any large rain. Two periods of effective moisture were calculated. The August 3rd rain produced one day with 7.87 mm of effective moisture. Some rain fell for five consecutive days from September 10 through 14 with 17 mm of effective moisture. The total effective moisture was almost one inch. The Pima area received only 40.9% as much total rain in the summer of 1966 as it had in 1965, but it had 60% as much effective moisture in 1966. As effective moisture, 1965 produced 1.64 inches compared with 1.0 inches

in 1966. The rainfall and effective moisture for 1966 are given in Figure 7.

Species Adaptation Studies

A species adaptation nursery was established at Pima in March and June 1966. The seedbeds were prepared by first bulldozer clearing and then pitting, and the species were seeded by drilling. A few of the trashy-seeded species had to be broadcast by hand. The March nursery is located near plot 28 and the June nursery near plot 85 of the 1966 seeding. Plant counts were made in November 1966 on both of these nurseries and also on those nurseries established in 1964 and 1965. The results are given in Tables 11, 12, 13 and 14. The nursery seeded in June 1966 had only a very few plants. The nursery seeded in March had very good emergence with only one out of thirteen species having no plants. As in the 1966 nursery at Congress, the Catalina strain of Boer lovegrass had the largest number of plants. All but 5 of the thirteen species had what would probably be a satisfactory stand.

In the various seeding studies it has been pointed out several times that a marked difference in response may occur between different times of seeding. The difference between the March and June seeded species studies is another case in point. The March seeded species were highly successful while the June seeded species were essentially failures. This points out the need for basic research in this direction to determine what factors promote successful seeding in the early part of the year. Steps are currently being taken in laboratory and greenhouse studies to delineate these factors.

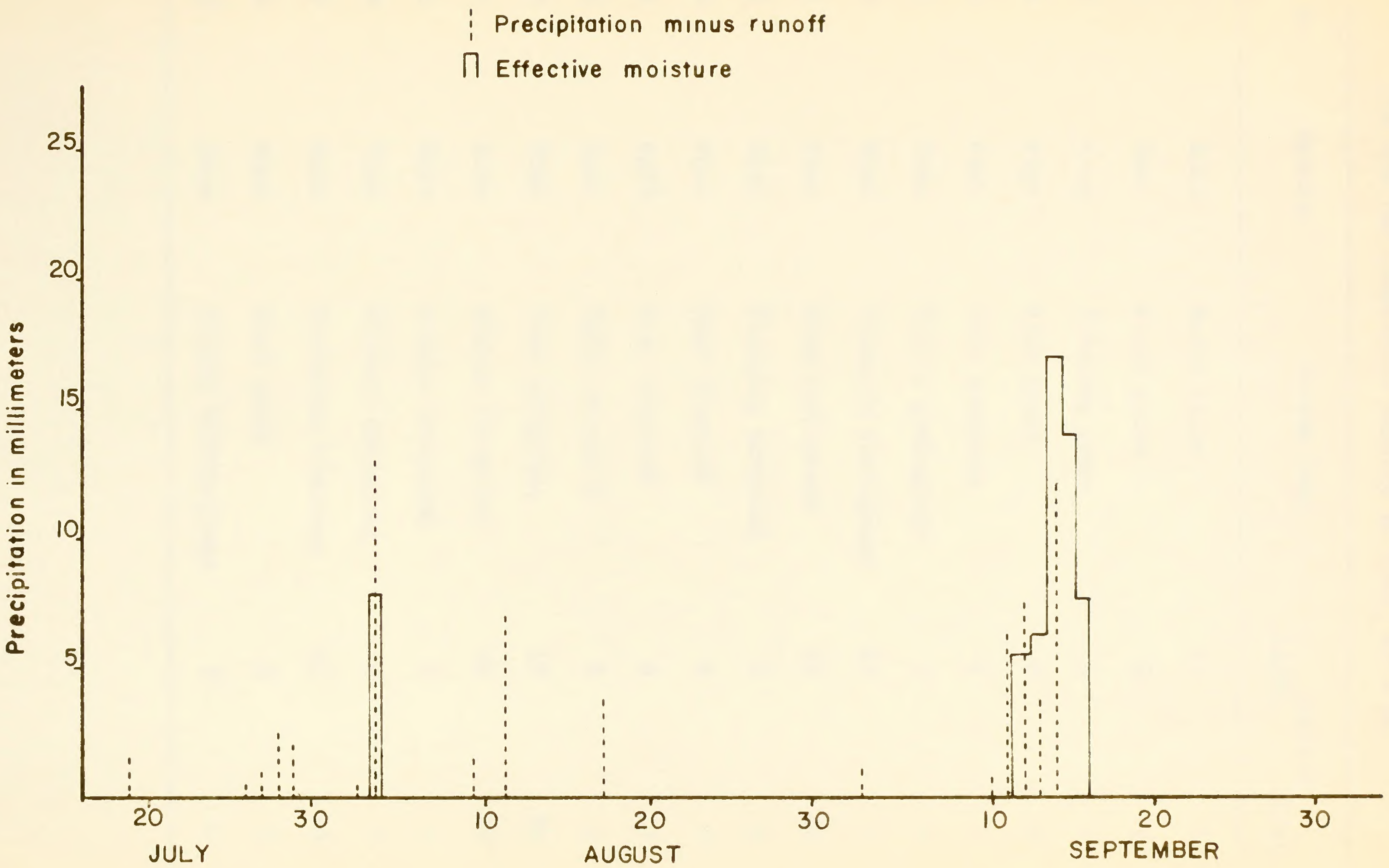


Figure 7 . A comparison between the precipitation and the resultant effective moisture for plant growth during the summer of 1966 at Pima, Arizona.

Table 11. The number of plants per 400 lineal feet planted in 1964 in the species adaptation nursery at Pima, Arizona.

Plot No.	Species	Common Name	Counted 11/65	Counted 11/66
1	Bohi	Hairy grama	11	1
2	Boer	Black grama	0	7
3	Bocu	Sideoats grama	1	0
4	Bogr	Blue grama	0	0
5	Paob	Vine mesquite	0	0
6	Paha	Hall's panicgrass	2	2
7	Paco	Pretoria panicgrass	15	4
8	Paan	Blue panicgrass	11	28
9	Spus	Creeping dropseed	5	1
10	Spar	Sand dropseed	0	8
11	Spfl	Mesa dropseed	4	1
12	Spco	Spike dropseed	2	4
13	Erch	Boer lovegrass	19	28
14	Ersu	Wilman lovegrass	20	15
15	Erin	Plains lovegrass	5	4
16	Trca	Arizona cottontop	0	0
17	Anis	Turkestan bluestem	32	48
18	Mupo	Bush muhly	0	0
19	Sema	Plains bristlegrass	0	10

Table 12. The equivalent number of plants per 500 square feet in the species adaptation nursery planted at Pima, Arizona in 1965. Counted November 1965 and November 1966.

Plot No.	Species	Common name and source		No. of Plants 1965	1966
1	Spco	Spike dropseed	A-14544	0	0
2	Spcr	Sand dropseed	A-16352	0	3
3	Spai	Alkali sacaton	A-13156	0	3
4	Spus	Creeping dropseed		0	1
5	Erch	Boer lovegrass		0	36
6	Ersu	Wilman lovegrass	A-11965	2	3
7	Peci	Buffelgrass		10	1
8	Erin	Plains lovegrass	A-14242	0	2
9	Anis[1]	Turkestan bluestem	A-14207-60	3	15
10	Erbi	Bicolor lovegrass	A-14152	0	1
11	Paan	Blue panicgrass	A-130	30	15
12	Paha	Hall's panicgrass	A-800	117	19
13	Paco	Pretoria panicgrass	A-12638	47	14
14	Paob	Vine mesquite	A-11711	0	2
15	Sema	Plains bristlegrass	A-14266	23	144
16	Trca*	California cottontop	A-8084	10	43
17	Bohi*	Hairy grama		245	361
18	Bocu*	Sideoats grama		3390	646
19	Boer*	Black grama		0	65
20	Bogr	Blue grama	A-12424	0	570
21	Mupo*	Bush muhly	A-13273	0	9
22	Peci*[2]	Buffelgrass		230	46
23	Anis*[2]	Turkestan bluestem		80	232

1 Caryopses
2 Trashy
* Broadcast seed

Table 13. The number of plants per 100 square feet planted in March, 1966 in the species adaptation nursery at Pima, Arizona.

Plot No.	Species	Common name and sources		No. of Plants
1	Erle	Lehmann lovegrass	A-68	108
2	Erle	Lehmann lovegrass	280-19(Apache)	80
3	Erch	Boer lovegrass	61-293-17 (Cata.)	194
4	Erch	Boer lovegrass	A-84	44
5	Erch	Boer lovegrass	A-12752	68
6	Ersu	Wilman lovegrass	A-111965	96
7	Anis	Turkestan bluestem	A-14207	34
8	Spco	Spike dropseed	A-14544	14
9	Paan	Blue panicgrass	A-16851	96
10	Paan	Blue panicgrass	A-130	26
11	Paco	Pretoria panicgrass	A-12638	90
12	Paco	Pretoria panicgrass	A-12638-M63	54
13	Boer	Black grama	A-3780	0

The 1965 nursery gave more response in 1966 than in 1965 with only one out of twenty-three species having no plants. The best stands were of sideoats grama, followed in order of decreasing numbers by blue grama, hairy grama, turkestan bluestem, and plains bristlegrass. The 1964 nursery had an increase in plant numbers over the 1965 count as well as more of the species responding. Turkestan bluestem had the largest plant count this year as it did in 1965, followed by blue panicgrass, Boer lovegrass, creeping dropseed, Wilman lovegrass, and plains bristlegrass.

Table 14. The number of plants per 100 square feet planted in June, 1966 in the species adaptation nursery at Pima, Arizona.

Plot No.	Species	Common name and sources		No. of Plants
1	Erch	Boer lovegrass	A-84	14
2	Erle	Lehmann lovegrass	A-64	14
3	Erle	Lehmann lovegrass	ARS61-280-19	0
4	Erch	Boer lovegrass	ARS61-293-17	2
5	Erch	Boer lovegrass	A-12757	4
6	Erle	Lehmann lovegrass	ARS61-280-19	2
7	Ersu	Wilman lovegrass	A-11965	2
8	Erle	Lehmann lovegrass	A014107	4
9	Paco	Pretoria panicgrass	A-12638	0
10	Paob	Vine mesquite	A-11171	0
11	Paco	Pretoria panicgrass	A-12638-M63	2
12	Paan	Blue panicgrass	A-130	4
13	Spco	Spike dropseed	A-14544	2
14	Spcr	Sand dropseed	A-16352	0
15	Anis	Turkestan bluestem	A-14207	2
16	Trca	Arizona cottontop	A-8084	0
17	Trca	Arizona cottontop	A-4404	0
18	Bocu	Sideoats grama	A-3603	0
19	Boer	Black grama	A-3730	0

THE FREDONIA AREA

This section of this report covers the progress of range seeding studies near Fredonia, Arizona for the years 1964, 1965 and 1966. The Fredonia area is in the big sagebrush range type in which the cool season grasses give the major response. There are an estimated 5.8 million acres of this range type in northern Arizona. A detailed description of the study area is included in previous progress reports. A diagram of the location of the various seeding studies in different years near Fredonia is presented in Figure 8, Contained in this section are reports on the progress of the following studies: (1) forage yields from selected seedings conducted in 1963, (2) herbicidal control of globe mallow and sagebrush in the 1963 and 1964 seedings, (3) the progress of the 1964 and 1965 seedings, (4) the nature and results from the 1966 seeding, and (5) results from species adaptation studies from 1962 through 1966. Data from climatic observations are also included with which the various results are correlated.

Forage Yields on Selected 1963 Seedings

During 1963, range seeding studies were conducted under a Pelleted Seeding Project. While no stands were obtained from sowing pelleted seed, good stands were obtained from sowing non-pelleted seed planted at the same time as a basis for comparison. These stands still persist and should provide useful data on the comparative forage yields from the well estab-

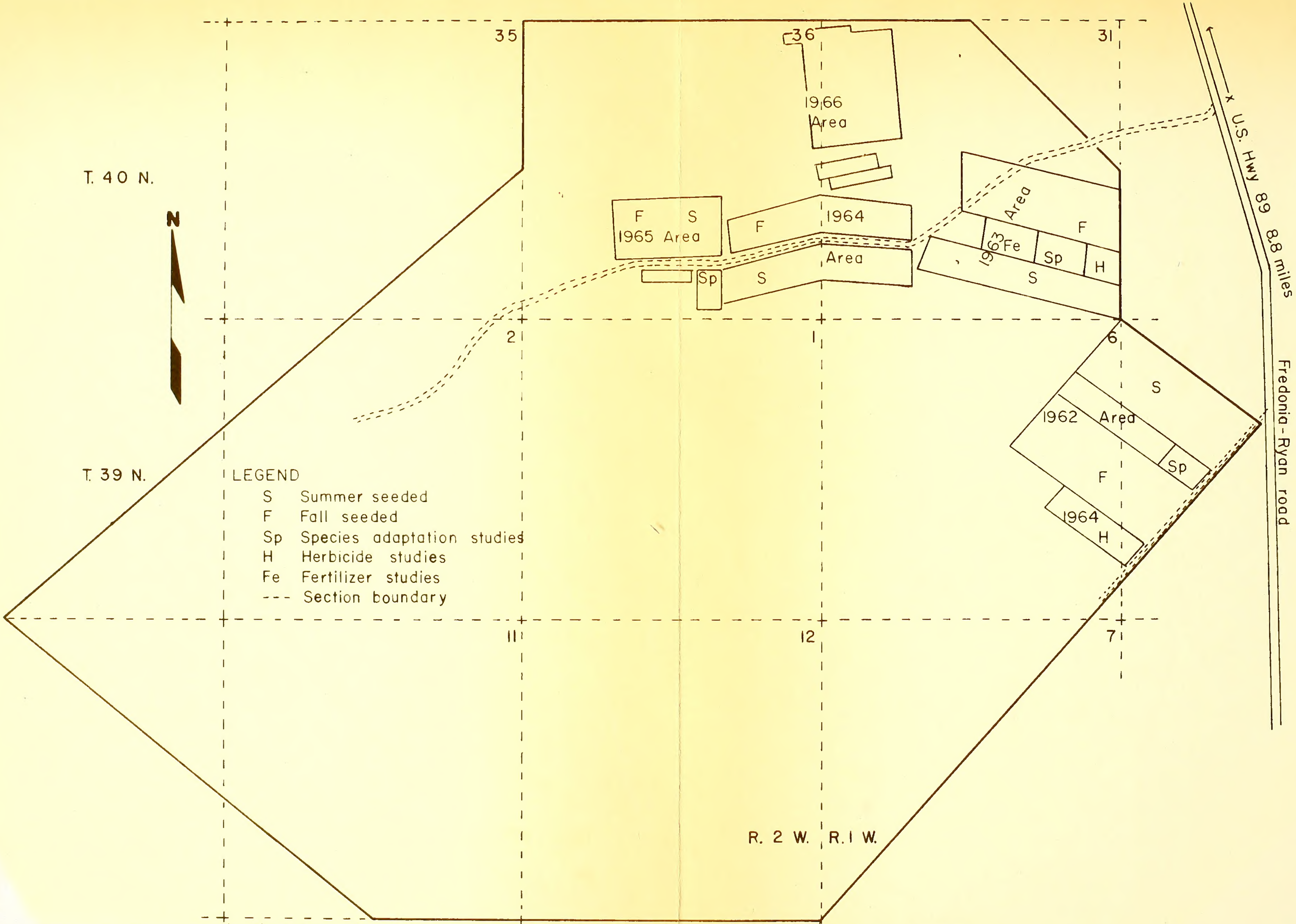


Figure 8. A diagram of the location of the range seeding studies near Fredonia, Arizona.

lished species. Therefore, forage was harvested from three species drilled into the following seedbeds: brush chopped, brush chopped and then pitted and disk plowed.

The species harvested were blue grama (summer seeded), crested wheatgrass, and Russian wildrye (fall seeded). Plant counts of the three species during 1963, 1964, 1965 and 1966 indicated a gradual reduction in stand from 1964 to 1966 on the drilled seedings. In terms of stand density in 1966, the crested wheatgrass had the largest number of plants followed by blue grama, and Russian wildrye. The stands from broadcasting were much poorer than those from drilling, but they have persisted at about the same level over the period from 1964 through 1966. Even though the drilled stands have undergone a reduction, they are still much better than the stands from broadcasting. The above results are illustrated by the comparisons presented in Table 15. The drilled stands were probably more dense than could be maintained with normal rainfall in the Fredonia Area. The stand from broadcasting, however, was inadequate. In 1964 the number of plants in the drilled plots was 6.6 times as many in the broadcast plots, and in 1966 the drilled plots still had 4.6 times greater number of plants. For this reason, only the drilled plots were sampled for yield comparisons.

To determine yields the grass was clipped from 10 quadrats randomly-located on each seedbed for each of the three species. The clipping height was one inch and the quadrat size was 1 by 5 feet. Each of the four replications of each seedbed was sampled. These forage samples were air-dried and the results in terms of pounds of forage per acre are presented in Table 16. For further comparisons, the number of plants per acre are also included in the table.

Table 15. The number of plants per 100 square feet on various seedbeds seeded in 1963 near Fredonia, Arizona.

Seedbed and method of seeding	Species and date of count					
	Blue grama		Crested wheatgrass		Russian wildrye	
	1964	1966	1964	1966	1964	1966
Drilled						
Non-treated	41	27	117	60	34	27
Herbicide sprayed	89	47	189	107	87	57
Chopped	252	167	275	145	171	101
Chopped & pitted	184	128	284	145	153	108
Disk plowed	190	111	272	169	171	124
Average	151	96	227	125	123	83
Broadcast						
Non-treated	1	0	8	4	0	0
Herbicide sprayed	3	1	5	6	1	2
Chopped	47	26	86	74	15	16
Chopped & pitted	16	9	64	55	44	30
Disk plowed	16	9	56	59	20	31
Average	16	9	44	40	16	16

Table 16. The yield of three range grass drill-seeded on various seedbeds in 1963 near Fredonia, Arizona. Yields are expressed in lbs. per acre and number of plants per acre as harvested in September 1966.

Species and seedbed preparation	Yield		
	lbs per acre	Number of plants per acre	Plants per pound
Crested wheatgrass			
Chopped	445	77,972	175.2
Chopped & pitted	525	64,468	122.7
Disk plowed	593	60,112	101.3
Average	521	67,518	129.6
Russian wildrye			
Chopped	180	46,173	256.5
Chopped & pitted	285	45,302	158.9
Disk plowed	304	67,953	223.5
Average	256	53,143	207.6
Blue grama			
Chopped	510	72,745	142.6
Chopped & pitted	279	55,756	199.8
Disk plowed	217	48,351	222.8
Average	335	58,806	175.5

In terms of forage in pounds per acre according to species there was 521 for crested wheatgrass, 335 for blue grama, and 256 for Russian wildrye. This was the same order of rank as given by the number of plants per acre, but an additional factor becomes evident by the weight-per-plant comparisons. From visual estimates it had been assumed that while the number of plants of Russian wildrye per acre was less, the weight per plant would be greater to give yields comparable to crested wheatgrass. The crested wheatgrass produced about 1.6 times more forage per plant besides having a stand 1.27 times more dense than Russian wildrye. This points out the need for more quantitative evaluations to be made of the adaptation and suitability of species for seeding in this area. Studies such as this will be continued as time permits in future studies.

Although the data in Table 16 also indicates that blue grama out yields Russian wildrye, other factors must be considered. It is very difficult to determine the number of blue grama plants per unit area because of their small size and dense population in the 1963 study area. The number of plants per acre given in the table was therefore only an approximation, as would be the weight per plant. Subsequent studies may indicate that blue grama will produce satisfactory yields if stands can be established. However, satisfactory stands can only be established in exceptionally favorable years.

The Control of Globe Mallow and Sagebrush on New Seedings

As pointed out in the 1965 Progress Report, there has been considerable competition between the seeded species and the native globe mallow. Globe mallow establishment is promoted by the more disturbed seedbeds, by drilling rather than broadcasting, and from summer seedings in contrast

to fall seedings. Also adding to the competition is the sagebrush which has been controlled to varying extent from seedbed preparation. In contrast to the globe mallow, the sagebrush was controlled better on the more extensively tilled seedbeds. One of the objectives of this project has been to evaluate the effectiveness of various seedbeds for establishing range seeding. The presence of competitive species obscures the effects due to seedbed preparation. Supplemental studies on the control of competitive species were, therefore, initiated having the following objectives: (1) to remove extraneous factors in the evaluations of seedbeds, (2) to test herbicidal control methods for the control of invading sagebrush and globe mallow, and (3) to determine the extent that these invading species compete with the seeded grasses.

These studies were conducted on selected seedbed preparations of the 1963 and 1964 seedings. Only those plots that were drill seeded were utilized. On each of the four replications of each seedbed a 20-foot strip was sprayed the length of each seedbed with the butyl ester of 2,4-D at the rate of one pound per acre (ae). On the 1963 area the herbicide was applied on the fall seeded crested wheatgrass and Russian wildrye on chopped, chopped and pitted, and disk plowed seedbeds. On the 1964 area the herbicide was applied on the summer seeded crested wheatgrass on chopped, chopped and pitted, disk plowed, and burned seedbeds. The spraying was done on May 2, 1966 when the globe mallow was in the early flower bud stage and was about eight inches in height. There was adequate soil moisture at the 6-inch depth and the wheatgrass and Russian wildrye were growing well. The location of the sprayed strips on each of the seedbeds is shown in Figures 9 and 10.

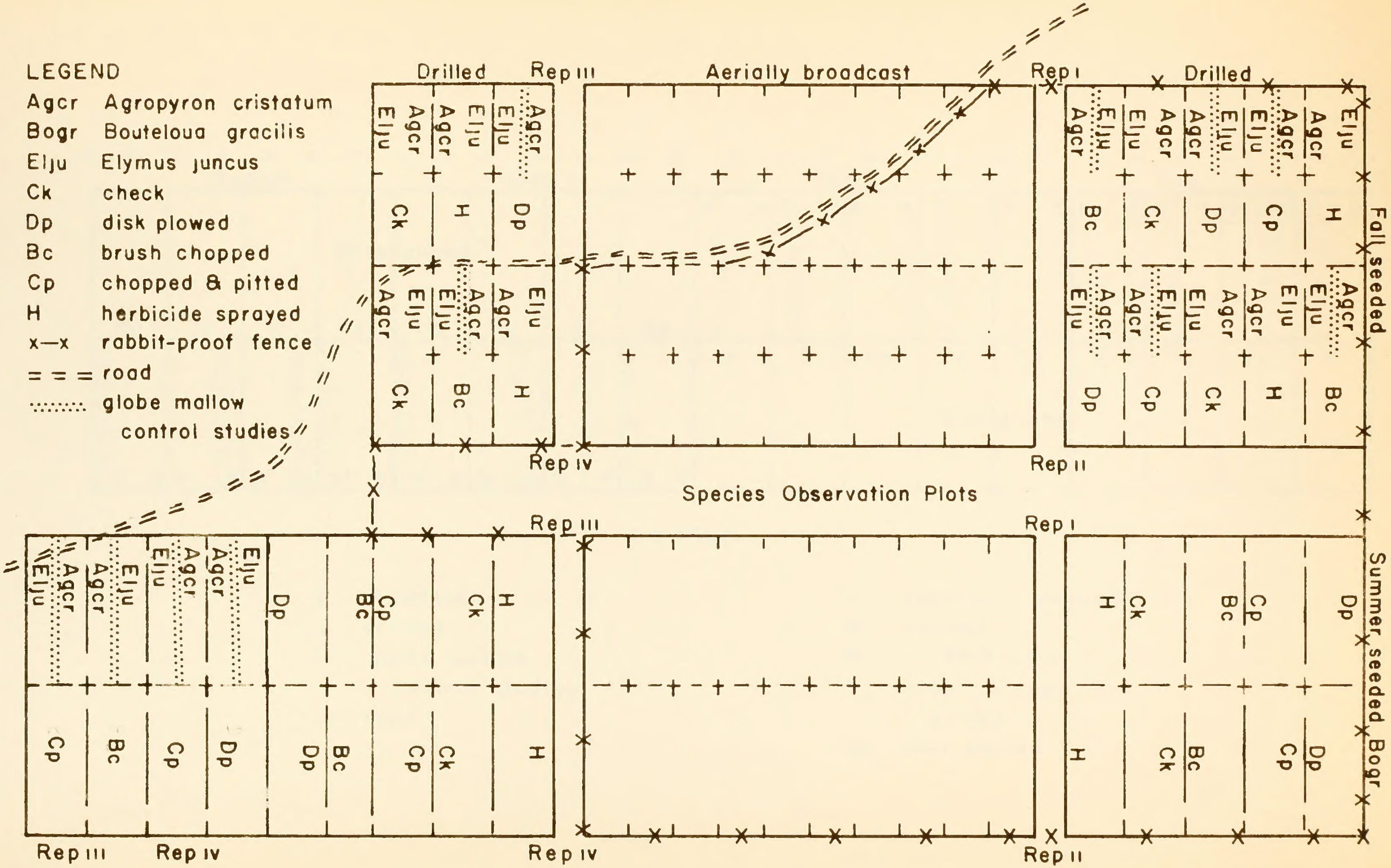


Figure 9. Location of globe mallow control studies on various seedbeds drill seeded in 1963 near Fredonia, Arizona

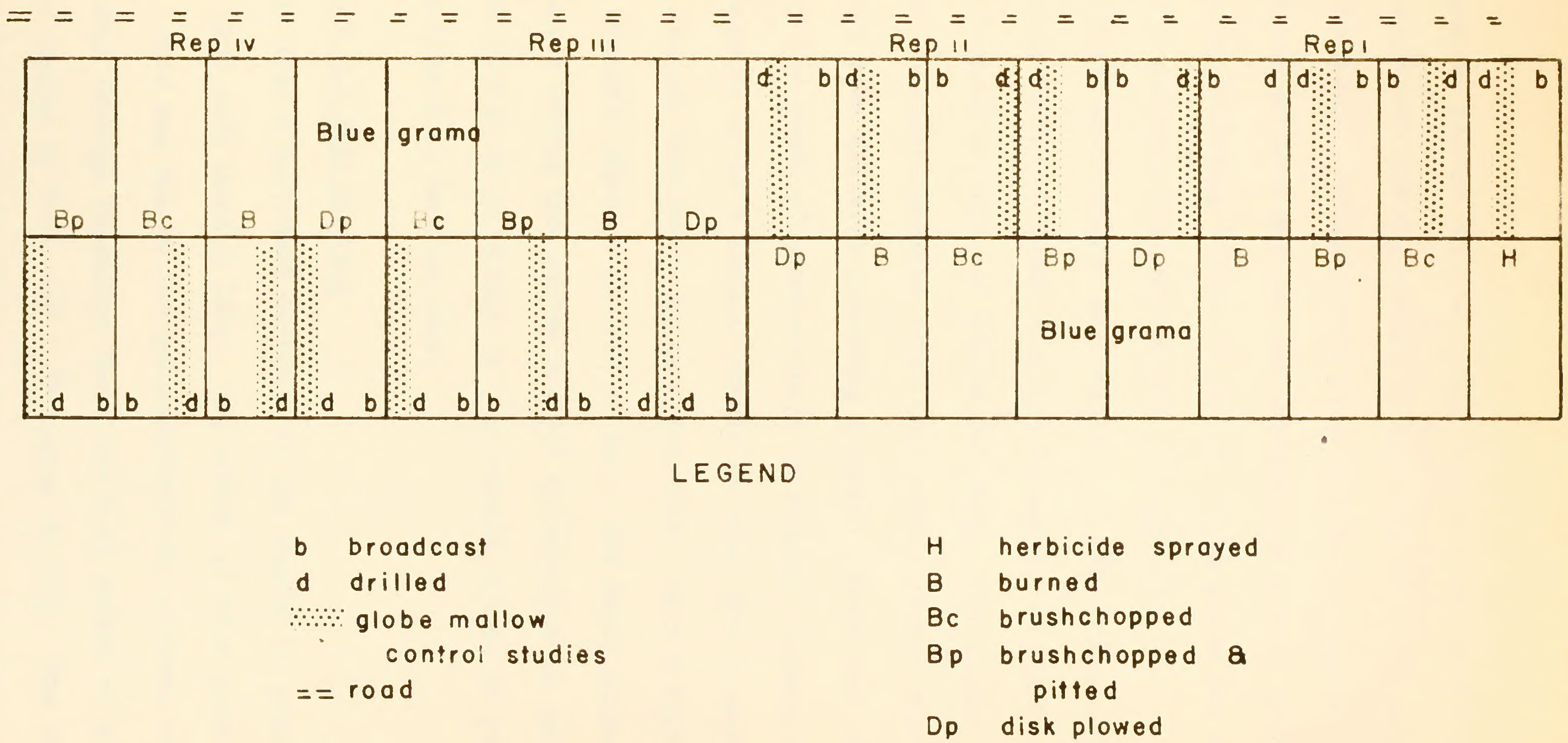


Figure 10. Location of the 1966 globe mallow and sagebrush control studies on various seedbeds drilled with crested wheatgrass July 1964.

The number of plants per 100 square feet for the seeded grasses, globe mallow, and sagebrush was determined in mid-July on both the sprayed and non-sprayed seedbeds. Forage yields were also determined by previously described methods on both sprayed and non-sprayed areas. These data are presented in the following Tables 17 and 18. Each yield was taken from ten 1 by 5-foot quadrats randomly placed in each plot.

On both areas good control was obtained on the globe mallow as illustrated by the reduction in stand from approximately 10 plants per 100 square feet to about 1 plant per 100 square feet. The extent of sagebrush control cannot be fully assessed until next year although visual estimations at this time indicate promising results. There was not a marked improvement in the yield of crested wheat or Russian wildrye in the 1963 area. This appears to be a logical result at this time because soil moisture was rapidly decreasing at spraying time. Only a limited growth of grass was possible whether sprayed or not. The major responses are expected to occur during the spring of 1967 if moisture is available. There has been little or no change in non-treated stands of globe mallow and sagebrush from 1965 through 1966.

The Progress of the 1964 Seeding

There has been a continual decrease in the number of plants in the 1964 seeding from 1964 through 1966. The stands of blue grama have almost disappeared. This was due to the comparatively dry summers of 1965 and 1966. From June through September there was 4.15 inches of precipitation in 1964, 2.72 inches in 1965, and 1.57 inches in 1966. The above average winter precipitation of 1965-66 probably was quite effective in promoting

Table 17. Forage yields and plant counts of crested wheatgrass, sagebrush, and globe mallow plants per 100 square feet on various seedbeds seeded in the fall of 1963 at Fredonia, Arizona and sprayed with 2,4-D in May 1966.

Grass and seedbed	Sprayed Plant counts				Non-Sprayed Plant counts			
	Grass	Sagebrush	G. Mallow	Forage Weight*	Grass	Sagebrush	G. Mallow	Forage Weight*
Crested wheatgrass								
Chopped-pitted	148	4.00	0.75	595	148	3.25	9.0	558
Brushchopped	152	7.50	0.75	565	179	10.0	4.75	563
Disk plowed	148	1.25	0.50	736	138	0.0	14.75	646
Average	149	4.25	0.67	631	155	4.42	9.50	587
Russian wildrye								
Chopped-pitted	101	3.25	4.50	262	104	3.25	11.0	268
Brushchopped	117	8.25	0.50	178	106	14.75	6.25	165
Disk plowed	114	1.50	0.25	360	156	2.75	13.50	259
Average	111	4.33	1.75	267	122	6.92	10.25	231

* pounds per acre

Table 18. A comparison of forage yield and plants per 100 square feet on various seedbeds seeded in July 1964 and sprayed with 2,4-D in May 1966.

Seedbed	Sprayed Number of Plants			Forage	Non-sprayed Number of Plants			Forage
	C. Wheat	Sage	G. Mallow	Yield	C. Wheat	Sage	G. Mallow	Yield
Brushchopped	136	4.0	8.5	242.2	132	5.5	34.3	169.9
Chopped & pitted	111	2.5	15.0	345.0	133	2.3	62.8	235.2
Disk plowed	114	0.5	15.5	325.0	107	1.3	49.5	308.0
Burned	70	0.0	13.5	154.6	93	0.3	33.3	169.0
Average	108	1.8	13.1	266.7	116	2.3	44.9	220.5

early growth and maintenance of the stand.

Plant counts were made on this stand in September of 1966. These data along with the data from counts made in previous years are presented in Table 19. They illustrate the reduction in the stand mentioned above. With respect to density of stand, crested wheatgrass ranks first followed by Russian wildrye and then blue grama. Most of the stands have remained generally in the same order of rank as they were in 1965. In fact, the stands have remained in the same stage of development as they had attained in 1965 in nearly all aspects.

It is believed that the 1964 seeding illustrates one facet of the reseeding problem in the Arizona Strip. Most stands as now constituted are not adequately developed to go into a grazing program even though they have had two full years for establishment. If one accepts the value of 50 to 100 plants per 100 square feet as being an adequate stand, then most of the crested wheatgrass stands and several of the Russian wildrye stands are adequate. However, due to low rainfall, most of these stands have not developed to a usable stage of forage production. It may be necessary from a range management standpoint, to withhold such stands from grazing until after a year of good moisture occurs. This situation is illustrated in Figure 11 showing a stand of crested wheatgrass drilled in the fall of 1964 into a burned seedbed having a stand density of 153 plants per 100 square feet. However, most of the plants were stunted. The question to be answered is whether this stand has the potential to develop when given adequate moisture. If it does not have the potential then more extensive seedbed preparation would be requisite for a successful range seeding. For example, Figure 12 shows a stand of crested

Table 19. The average number of plants per 100 square feet per various grasses planted on different seedbeds in 1964 near Fredonia, Arizona.

Species, time and seedbed	Method of seeding & date of count								
	Broadcast			Drilled			Average		
	1964	1965	1966	1964	1965	1966	1964	1965	1966
Agcr* - Summer									
Herbicide	11	4	3	722	280	95	367	142	49
Brushchopped	91	50	50	810	313	170	451	182	110
Chopped-pitted	102	76	48	632	301	106	367	189	77
Disk plowed	70	95	64	445	199	82	258	147	73
Burned	80	16	11	357	126	77	219	71	44
Average	71	48	35	593	243	106			
Bogr - Summer									
Herbicide	232	4	0	307	20	0	269	12	0
Brushchopped	253	28	8	102	6	2	178	17	5
Chopped-pitted	198	53	16	79	5	2	139	29	9
Disk plowed	182	9	4	51	0	0	117	5	2
Burned	187	14	5	49	6	3	118	10	4
Average	210	21	7	118	7	1.4			
Agcr - Fall									
Herbicide sprayed		0	0		148	62		74	31
Brushchopped		0	1		78	47		39	24
Chopped-pitted		22	13		187	88		105	51
Disk plowed		1	6		153	78		77	42
Burned		2	3		316	153		159	78
Average		5	5		176	107			
Elju - Fall									
Herbicide sprayed		0	1		164	29		82	15
Brushchopped		0	0		114	37		57	19
Chopped-pitted		9	7		202	67		106	37
Disk plowed		1	2		63	36		32	19
Burned		12	5		202	89		107	47
Average		4	3		149	65			

*Agcr - Crested wheatgrass
Elju - Russian wildrye
Bogr - Blue grama

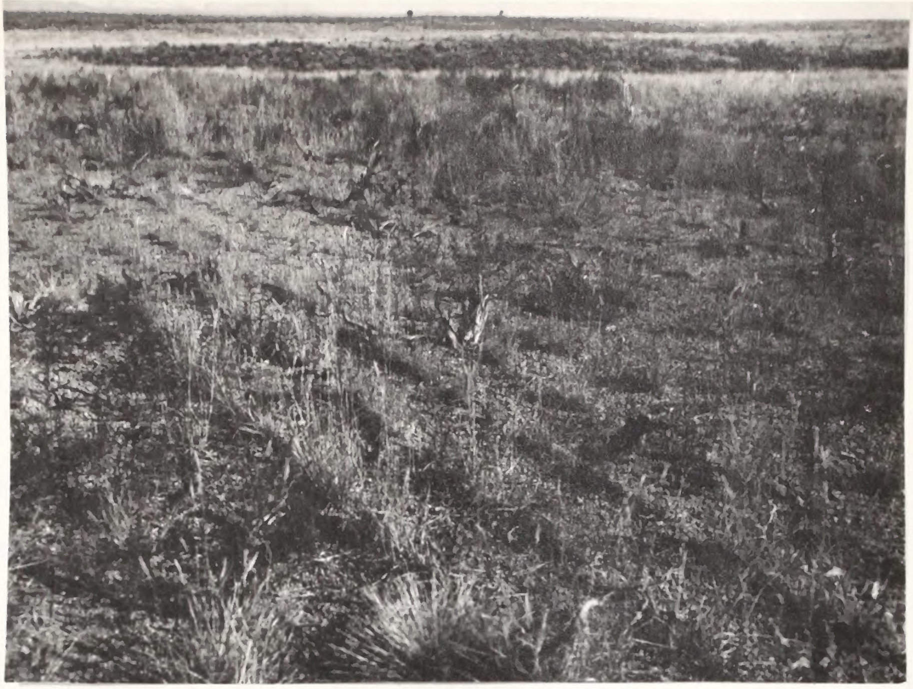


Figure 11 Crested wheatgrass drilled into a seedbed prepared by burning away the sagebrush. Planted September 1964 and photographed October 1966.

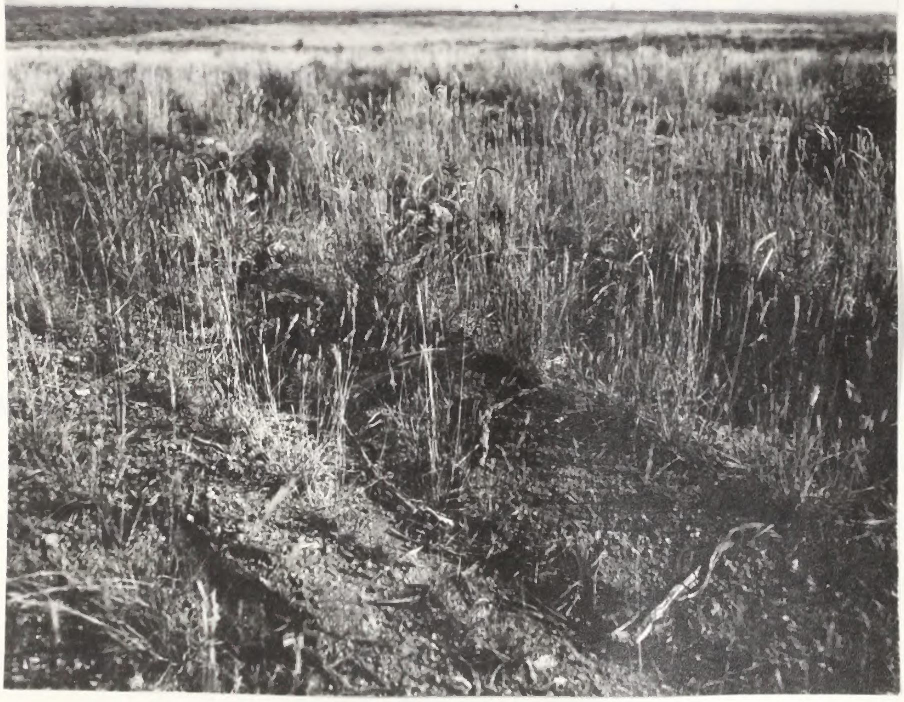


Figure 12 Crested wheatgrass drilled into a brush-chopped and pitted seedbed showing establishment on the berm of the pit. Seeded September 1964 and photographed October 1966.

wheatgrass drilled in the fall of 1964 into a chopped and pitted seedbed. While the stand on this seedbed averaged only 88 plants per 100 square feet it had much more vigor and height and obviously more than twice the forage than the stand on the burned seedbed. It is still too early to clearly distinguish what constitutes an acceptable stand or a required seedbed preparation.

Progress of the 1965 Seeding

In 1965 on the Fredonia area, six range grasses (crested wheatgrass, Siberian wheatgrass, Russian wildrye, blue grama, sand dropseed, and spike dropseed) were seeded in the summer by broadcasting and by drilling both before and after the seedbeds were prepared. The seedbeds were prepared by either plowing with a brushland plow or by brushchopping. A plant count was made in September 1965 and again in October 1966; the results of these counts are given in Table 20.

From 1965 to 1966 there was a small overall drop in plant numbers. With so few plants present, only limited conclusions can be drawn from these data. There was very little difference between drilling and broadcasting and not much difference between plowed and brushchopped seedbeds. Of the six range grasses seeded, the Siberian wheatgrass and the crested wheatgrass increased in plant numbers. The other four decreased in number and at the time of the 1966 count there was almost no plants present of blue grama, sand dropseed, or spike dropseed. The Siberian wheatgrass had the largest number of plants followed by the crested wheatgrass. There were only a few plants of Russian wildrye.

Table 20. The average number of plants per 100 square feet on various seedbeds planted by various methods near Fredonia in the summer of 1965.

Seedbed and seeding method	Crested wheatgrass 9/65	Crested wheatgrass 9/66	Siberian wheatgrass 9/65	Siberian wheatgrass 9/66	Russian wildrye 9/65	Russian wildrye 9/66	Blue grama 9/65	Blue grama 9/66	Spike dropseed 9/65	Spike dropseed 9/66	Sand dropseed 9/65	Sand dropseed 9/66	Average 9/65	Average 9/66
Drilled														
Plowed before seeding	17	26	24	31	15	7	4	0	4	0	1	0	11	11
Brushchopped before seeding	14	37	16	28	23	12	3	0	2	3	3	1	10	14
Brushchopped after seeding	15	12	24	18	11	4	7	0	1	0	5	0	10	6
Average	15	25	21	26	16	8	5	0	2	1	3	0.3		
Broadcast														
Plowed before seeding	10	27	18	47	24	13	6	0	3	0	2	0	10	15
Plowed after seeding	3	12	1	12	3	7	0	0.3	[illegible]0	0.3	1	0	1.3	5
Brushchopped before seeding	14	42	26	70	9	12	3	0	1	2	1	0	9	21
Brushchopped after seeding	25	12	42	17	28	2	2	0	3	0	7	0	18	5
Average	13	23	22	39	16	9	3	0	2	0.8	3	0		

It is interesting to note a trend in the 1965 summer seeding between brushchopping before seeding and brushchopping after seeding. The brushchopping before seeding resulted in an increase in plant numbers during 1966 while brushchopping after seeding resulted in a decrease. It is suggested that a difference in moisture levels at the soil surface may account for this trend. The brushchopping after seeding promoted germination from scanty precipitation. The seedlings therefrom then died because of inadequate moisture. In other words, the more deeply planted seeds would not germinate until comparatively more precipitation had occurred to wet a greater volume of soil. The seedlings therefrom would become better developed before soil moisture becomes limiting. This supposition agrees in principle with the difference noted between the stands from drilling and broadcasting.

In the 1965 fall seeding at Fredonia, the same methods of seeding, seedbed treatments, and grasses, with the exception that pubescent wheatgrass was seeded in place of blue grama, were used as in the summer seeding. There were over five inches of rainfall during the winter of 1965-66 and over an inch of rainfall in May 1966. The plant count in October 1966 of the 1965 fall seeding seems to indicate that the fall seeding was able to use some of this winter and spring moisture as a fair stand of grass was obtained by some of the better combinations of grass, method of seeding, and seedbed treatments. But, still unanswered is the question of why the fall seeding was able to use this winter and spring moisture but the summer seeding did not use it. The results of the October 1966 count of the 1965 seeding are given in Table 21. Drilling was more

Table 21. The average number of seeded and competitive plants per 100 square feet on various seedbeds planted by various methods near Fredonia in the fall of 1965.

	Species seeded						Averages		
Seedbed and seeding method	Crested wheatgrass	Siberian wheatgrass	Pubescent wheatgrass	Russian wildrye	Spike dropseed	Sand dropseed	Grass	Sage	Globe Mallow
Drilled									
Plowed before seeding	123	128	105	68	2.5	3	72	1	3
Brushchopped before seeding	54	47	97	1.5	6.5	0	34	5	10
Brushchopped after seeding	22	24	77	3	0	0	21	5	9
Average	66	66	93	24	3	1			
Broadcast									
Plowed before seeding	46	37	19	16	8	5	22	1	4
Plowed after seeding	39	68	27	9	1	0.5	24	1	3
Brushchopped before seeding	9	6	5	0	0	0	3	5	14
Brushchopped after seeding	54	33	63	6	0.8	0.5	26	6	11
Average	37	36	29	8	2.4	1.5			

effective than broadcasting and the plowed seedbed treatments were more effective than the brushchopped treatments. As might be expected, the drilled, plowed-before-seeding was the most effective seeding method. For the larger seeded species, plowing either before or after broadcasting promoted similar stands. For the smaller seeded species such as the drop seeds, plowing after broadcasting covered many of the seeds too deeply. It also covered some of the wheatgrass too deeply but it was observed that those wheatgrass or wildrye plants that had emerged from these seedings were more vigorous. This is an indication that more attention should be given to planting wheatgrass as deeply as possible without hindering emergence. As previously discussed, the deeper planted seeds would germinate only under moisture conditions that would be more favorable for stand establishment.

Brushchopping before seeding favored stand establishment from drilling, but brushchopping after seeding favored stand establishment from broadcasting. These results pertain only to the 1965 fall seeding and should be interpreted only in terms of soil moisture availability.

The pubescent wheatgrass stands had the largest number of plants followed closely by crested wheatgrass and Siberian wheatgrass. Russian wildrye performed well only when drilled on plowed seedbeds, There were only a few of the dropseeds and these occurred most often in depressions. This may indicate that pitting should be tested as a method of establishing dropseeds. Most of the species were small seedlings under two inches in height. The most vigorous species was pubescent wheatgrass which often had plants headed out.

In the 1965 seeding the number of sagebrush and globe mallow plants, counted in October 1966, was small in comparison with 1963 and 1964 seedings. The plowed seedbeds had a much smaller number of sagebrush plants than the brushchopped as might be expected. The same was true for the globe mallow which is the opposite of the trend found in the 1963 and 1964 seeding. No reason is apparent at this time for this opposite trend of globe mallow establishment.

1966 Seeding

The 1966 seeding was a continuation of the studies started in 1965 concerned with the extensive testing of promising species under various seeding methods. The 1966 studies were concerned with the following major factors:

1. A comparison of different seedbeds prepared by brush chopping, disk plowing, burning, and herbicide spraying.
2. A comparison of six species of grass on all seedbeds with two methods of seeding. These species were crested wheatgrass (*Agropyron desertorum*), siberian wheatgrass (*A. sibericum*), pubescent wheatgrass (*A. tricophorum*), Russian wildrye (*Elymus juncus*), spike dropseed (*Sporobolus contractus*), and sand dropseed (*S. cryptandrus*).
3. A comparison of seeding methods consisting of broadcasting and drilling before and after seedbeds were prepared.
4. A comparison of the time of seeding in July with October.

The experimental design was a randomized block with four replications. The combination of the various factors can be more readily visualized by referring to the plot diagram in Figure 22 for the summer seeding and to Figure 23 for the fall seeding.

LEGEND

D	drilled
B	broadcast
Bu	burned
H	herbicide sprayed
PA	plowed after seeding
PB	plowed before seeding
BA	brush chopped after seeding
BB	brush chopped before seeding

Agcr	crested wheatgrass
Agsi	siberian wheatgrass
Agtr	pubescent wheatgrass
Elju	Russian wildrye
Spcr	sand dropseed
Spco	spike dropseed

Agcr Spcr Elju Agsi Agtr Spco	Agsi Spcr Spco Elju Agcr Agtr	Spcr Agcr Elju Agsi Agtr Spco	Spcr Spco Agcr Elju Agsi Agtr	Agsi Spcr Spco Elju Agcr Agtr	Agcr Agsi Elju Spcr Agtr Spco	Agcr Agsi Elju Spcr Spco Agtr	Elju Agtr Spcr Agcr Spco Agsi	Spco Agtr Spcr Agcr Elju Agsi	Agsi Elju Spcr Agtr Spco Agcr	Spco Spcr Agcr Agtr Elju Agsi
B PB 34	D H 35	B H 36	D PB 37	B Bu 38	D BA 39	D Bu 40	D BB 41	B BB 42	B BA 43	B PA 44

Agcr Elju Agsi Agtr Spcr Spco	Spco Agsi Agtr Spcr Agcr Elju	Spco Agtr Elju Spcr Agcr Agsi	Agcr Spco Spcr Elju Agtr Agsi	Agtr Agcr Agsi Elju Spco Spcr	Agtr Elju Spco Agsi Spcr Agcr	Spco Agsi Agcr Elju Agtr Spcr	Agcr Elju Spcr Spco Agsi Agtr	Agcr Agsi Elju Spcr Agtr Spco	Spcr Spco Agtr Agcr Agsi Elju	Agcr Elju Spco Agsi Agtr Spcr
B H 23	D H 24	D Bu 25	B BA 26	D PB 27	B Bu 28	B BB 29	B PA 30	B PB 31	D BA 32	D BB 33

Agcr Spcr Elju Agsi Spco Agtr	Agsi Agtr Agcr Spcr Elju Spco	Spcr Spco Agcr Elju Agsi Agtr	Agsi Agcr Spco Agtr Elju Spcr	Elju Agsi Spco Agtr Agcr Spcr	Spco Agtr Elju Spcr Agcr Agsi	Spcr Agcr Elju Agsi Spco Agtr	Agsi Agtr Spco Spcr Elju Agcr	Agsi Agtr Spco Elju Spcr Agcr	Spco Spcr Agsi Agtr Elju Agcr	Spcr Agsi Agcr Elju Agtr Spco
B BB 12	D BA 13	B Bu 14	D PB 15	B PA 16	B PB 17	B H 18	D Bu 19	D BB 20	B BA 21	D H 22

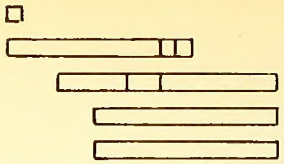
Spco Agcr Spcr Elju Agsi Agtr	Spcr Elju Agsi Spco Agcr Agtr	Spco Agcr Spcr Elju Agsi Agtr	Agtr Spcr Spco Elju Agsi Agtr	Elju Spco Agcr Spcr Agtr Agsi	Elju Spcr Agcr Agtr Spco Agsi	Agcr Agtr Elju Spcr Agsi Spco	Agtr Spco Spcr Agcr Agsi Elju	Spcr Elju Agtr Spco Agsi Agcr	Agsi Agcr Spcr Agtr Spco Elju	Agcr Agtr Elju Spcr Spco Agsi
B PB 1	B PA 2	B BB 3	B Bu 4	B BA 5	D H 6	D BB 7	D Bu 8	D BA 9	B H 10	D PB 11

Figure 22 A plot diagram showing seedbed preparation, method of seeding, and species seeded in July 1966 near Fredonia, Arizona.

LEGEND

Agtr
Agsi
Elju
Spcr
Agcr
Spco
B PB 88

D	drilled	Agcr	crested wheatgrass
B	broadcast	Agsi	siberian wheatgrass
Bu	burned	Agtr	pubescent wheatgrass
H	herbicide sprayed	Elju	Russian wildrye
PA	plowed after seeding	Spcr	sand dropseed
PB	plowed before seeding	Spco	spike dropseed
BA	brushchopped after seeding	BB	brushchopped before seeding


actual replication arrangement

Agsi	Elju	Agcr	Elju	Spco	Agsi	Agsi	Agtr	Agtr	Agtr	Agtr
Spco	Spco	Agsi	Agsi	Agsi	Spco	Agtr	Agsi	Agsi	Agcr	Agsi
Spcr	Agtr	Spco	Agcr	Spcr	Agtr	Spcr	Elju	Elju	Spcr	Elju
Elju	Spcr	Agtr	Spcr	Elju	Agcr	Agcr	Spco	Spcr	Agsi	Spcr
Agtr	Agcr	Elju	Spco	Agtr	Spcr	Spco	Spcr	Agcr	Elju	Agcr
Agcr	Agsi	Spcr	Agtr	Agcr	Elju	Elju	Agcr	Spco	Spco	Spco
B PA 78	B BA 79	B BB 80	D Bu 81	D BB 82	B Bu 83	D BA 84	D PB 85	B H 86	not treated	D H 87

Spcr	Elju	Agcr	Agcr	Agtr	Agsi	Spcr	Spcr	Agtr	Spcr	Agtr
Agtr	Agsi	Spcr	Elju	Spco	Agcr	Agcr	Elju	Agsi	Elju	Spco
Elju	Agtr	Elju	Spcr	Agsi	Spcr	Agtr	Agtr	Elju	Spco	Agsi
Agcr	Agcr	Spco	Spco	Elju	Elju	Spco	Spco	Agcr	Agcr	Elju
Agsi	Spcr	Agtr	Agtr	Agcr	Agtr	Agsi	Agcr	Spco	Agtr	Spcr
Spco	Spco	Agsi	Agsi	Spcr	Spco	Elju	Agsi	Spcr	Agsi	Agcr
D BB 67	D BA 68	B PB 69	B PA 70	B Bu 71	B BB 72	D PB 73	D Bu 74	B BA 75	D H 76	B H 77

Spcr	Elju	Spco	Agtr	Spcr	Agcr	Spcr	Agsi	Agsi	Elju	Spco
Agtr	Agsi	Agtr	Agsi	Agtr	Spcr	Spco	Agtr	Agcr	Agcr	Spcr
Agsi	Agcr	Spcr	Spco	Elju	Agsi	Elju	Elju	Spcr	Spcr	Agtr
Spco	Agtr	Elju	Spcr	Agcr	Spco	Agsi	Spcr	Elju	Agtr	Agsi
Elju	Spco	Agsi	Elju	Agsi	Elju	Agcr	Spco	Agtr	Agsi	Elju
Agcr	Spcr	Agcr	Agcr	Spco	Agtr	Agtr	Agcr	Spco	Spco	Agcr
D H 56	B BA 57	D BB 58	D Bu 59	B H 60	B PB 61	B PA 62	D PB 63	B Bu 64	D BA 65	B BB 66

Agsi	Agcr	Agsi	Agsi	Agtr	Spco	Agtr	Agtr	Spco	Agtr	Spco
Elju	Spco	Elju	Spco	Spco	Agtr	Agcr	Agsi	Agtr	Agcr	Spcr
Agtr	Agtr	Agcr	Agcr	Spcr	Spcr	Elju	Elju	Agsi	Elju	Elju
Agcr	Spcr	Spcr	Spcr	Elju	Elju	Spco	Agcr	Elju	Spco	Agsi
Spcr	Elju	Agtr	Agtr	Agsi	Agsi	Spcr	Spco	Agcr	Spcr	Agtr
Spco	Agsi	Spco	Elju	Agcr	Agcr	Agsi	Spcr	Spcr	Agsi	Agcr
D PB 45	B H 46	D BA 47	D Bu 48	D BB 49	D H 50	B BA 51	B Bu 52	B BB 53	B PA 54	B PB 55

Figure 23. A plot diagram showing seedbed preparation, method of seeding, and species seeded in October, 1966 near Fredonia, Arizona.

Each seedbed plot was 150 by 200 feet in size. The plot size for each species was 25 by 200 feet. Each plot was identified by a lettered or numbered stake placed in the right-hand corner of each plot in accordance with the plot diagram. The soil conditions were dry at the time of both the summer and the fall seedings. The seeding rate in pounds per acre for the various species was as follows: crested wheatgrass, 8.0; pubescent wheatgrass, 10.8; Siberian wheatgrass, 7.5; Russian wildrye, 7.0; spike dropseed, 2.2; and sand dropseed, 2.2. The plowing was done with a tandem disk and the brush chopping was done with a Servis Brush-chopper. The herbicide spray used was the butyl ester of 2,4-D at the rate of 4 pounds per acre (ae). The spraying was done on May 1, 1966 for all herbicide plots. The burned plots were sprayed with a contact herbicide was done about two weeks before the burning, and the burning was done with the aid of a propane gas torch just prior to the seedings.

Due to very limited precipitation there was very poor emergence of summer seeded species at the time of the count in October 1966. The results of this plant count are given in Table 22. Because of the very poor emergence, no evaluation of the seedbed treatments can be made at this time. The emergence of all species was very poor, but the sand dropseed and the spike dropseed emerged better than the other grasses. The better emergence of the dropseeds by the fall of 1966 was the opposite of the trend found in the 1965 summer seedings. No reason is apparent at this time for these opposite trends. It was observed in the 1966 summer seeding as it also is in the 1965 seeding that the dropseeds often emerged from low spots and depressions. One plot with a very large

Table 22. The average number of plants per 100 square feet on various seedbeds planted by various methods near Fredonia in the summer of 1966.

Methods of seeding and seedbed preparation	Species seeded						
	Agcr	Agsi	Agtr	Elju	Spco	Spcr	Average
Drilled							
Plowed before seeding	0	0	2	0	3.25	8	2.2
Chopped before seeding	2.75	0.50	1	0	15	2.75	3.8
Chopped after seeding	0	0	0.25	0	9	3.50	2.1
Burned	0	0	0	0	4.75	3.25	1.3
Herbicide	0	0	0	0	1.25	3.75	0.8
Broadcast							
Plowed before seeding	0	0	0	0	7.75	2.75	1.8
Plowed after seeding	0	0.25	0	0	0.75	0.75	0.3
Chopped before seeding	0.50	0.25	0.75	0	11.25	4.75	2.9
Chopped after seeding	0	0.50	0	0	34.75*	2	6.2
Burned	0	0	0	0	0.75	0.25	0.2
Herbicide	0	0	0	0	0	1.25	0.2
Average	0.3	0.1	0.4	0	8.0	3.1	

* One plot with numerous plants is in a run-off water area.

number of spike dropseed plants was along a small wash that carried run-off water. As noted before in this report, pitting might well be tried as a seedbed preparation for the dropseeds. A plant count of sagebrush and globe mallow plants was made in October 1966, but numbers of plants were small and no correlation of plant numbers with seedbed preparation can be made at this time.

Observation of a successful commercial seeding made in the winter of 1963 near Fredonia promoted the decision to try seeding in the winter. An area was disk plowed at the time of the fall 1965 seeding. Seedings of crested wheatgrass were made by drilling and by broadcasting on January 13 and February 25. The plots, 75 by 200 feet, were randomized and were replicated four times. The soil was very moist at the time of both seedings. The emergence was very poor and the only conclusions made were that these seedings were failures. Supplemental studies such as these should be continued to determine the cause of such failures.

Species Adaptation Nurseries

A species adaptation nursery was established in both July and October of 1966. Two seedbeds traversed the length of the nursery; each were 100 feet in width. Each species was seeded across each seedbed; one seedbed was disk plowed and the other was brushchopped. Each species plot measured about 10 by 200 feet. Nineteen different species or varities were seeded in July and twenty in October. All the nurseries established since 1962 for the evaluation of various species for seeding on the sagebrush rangelands of Arizona were counted in 1966. The current status in terms of number of plants per 100 square feet is shown for all species in all

nurseries in the following Tables 23, 24, 25, 26, and 27. The older nurseries, 1962, 1963 and 1964 have reached a steady state that might be called normal for the amount of precipitation of this area. The number of plants of each species will fluctuate from year to year according to the existing conditions. There was a general increase in all nurseries from 1965 through 1966. In the 1965 summer-seeded nursery the emergence was very poor in the fall of 1965. Additional plants were established in 1966, and it is thought that the plant population will continue to increase. The fall-seeded 1965 nursery had better emergence than the summer-seeded 1965 nursery as was true of the 1965 field seedings. There was practically no emergence from the summer-seeded 1966 nursery. In a year of high summer rainfall about all species planted will emerge, as illustrated in the 1963 summer-seeded nursery. It has been observed that certain species can be established under favorable conditions and they will maintain their stand densities, but they produce very little forage or seed such as black grama, for example. The species which seem to be the more adapted range grasses for this area are able to grow vigorously, maintain a good population, and produce a good seed crop. These are the wheatgrasses, Russian wildrye, certain selections of Indian ricegrass, and possibly some of the dropseeds. The data from the nurseries also indicate that certain ricegrasses and dropseeds can be established under unfavorable conditions, but it may require two or three years to get a good stand. The data from the nurseries also indicate that four-wing saltbush may be established but it is slow growing and may require several years for noticeable results. Two wheatgrasses which apparently can be established during years of low rainfall are beardless wheatgrass (Agropyron

Table 23. The number of plants per 100 square feet in a species adaptation nursery planted in July and October, 1962 near Fredonia, Arizona.

Plot No.	Species	Common name	Date Counted			
			8/27/63	8/21/64	9/21/65	7/1/66
		Summer Seeded				
1	Bocu	Sideoats grama	8	9	2	6
2	Boer	Black grama	10	8	1	4
3	Bogr	Blue grama	9	4	3	2
4	Atca	Four-wing saltbush	2	5	3.0	5
5	Orhy	Indian ricegrass	11	6	5.5	12
6	Sema	Plains bristlegrass	4	9	4.0	0
7	Muwr	Spike muhly	97	12	49.0	12
8	Anis	Turkestan bluestem	0	0	1.0	1
9	Erbi	Bicolor lovegrass	18	1	1.5	0
10	Erle	Lehmann lovegrass (3506)	2	1	0	0
11	Erle	Lehmann lovegrass (A-68)	327	1	0	0
12	Ercu	Weeping lovegrass	24	0	0.5	0
13	Erch	Boer lovegrass	156	0	0	0
14	Spai	Alkali sacaton	25	29	12.0	21
15	Spus	Creeping dropseed	51	8	6.5	5
16	Spcr	Sand dropseed	98	44	20.0	24
17	Spco	Spike dropseed	617	136	89.0	116
18	Agcr	Crested wheatgrass	34	25	27.0	56
		Fall Seeded				
1	Agcr	Crested wheatgrass	17	43	19.5	36
2	Elju	Russian wildrye (Colo.)	30	44	32.5	42
3	Elju	Russian wildrye (Utah)	7	22	12.0	17
4	Agcr	Crested wheatgrass (N. Dak.)	13	28	15.5	28
5	Agin	Intermediate wheatgrass	37	49	26.5	31
6	Agsm	Western wheatgrass (Utah)	5	23	12.5	22
7	Agin	Intermediate wheatgrass (Amur)	15	18	10.0	16
8	Agtr	Pubescent wheatgrass	35	48	21.0	30
9	Elci	Giant wildrye	2	2	3.5	4
10	Agsi	Siberian wheatgrass	33	96	47.5	39
11	Elsa	Salina wildrye	6	6	3.5	5
12	Sami	Burnet	5	0	0.0	2
13	Atca	Four-wing saltbush	0	2	0.5	8
14	Orhy	Indian ricegrass	10	12	6.5	3
15	Eula	Winterfat	0	0	0.0	0
16	Orhy	Indian ricegrass (Wyo.)	0	0	0.5	0
17	Orhy	Indian ricegrass (Wyo.-Tucson)	1	0	0.0	0
18	Orhy	Indian ricegrass (Red -desert)	2	1	0.5	0
19	Sihy	Squirreltail (Springerville)	11	11	12.0	26

Table 24. The number of plants per 100 square feet in a species adaptation nursery planted in July and September, 1963 near Fredonia, Arizona.

Plot No.	Species	July seeded Common name and source	Date Counted 8/23/63	 8/20/64	 8/8/65	 7/1/66
1	Bogr	Blue grama (Comm'l)	972	273	140	158
2	Bocu	Sideoats grama A-3603	446	253	110.5	135
3	Boer	Black grama A-3730	392	184	96.5	119
4	Sami	Burnet A-14173	14	1	2.0	10
5	Atca	Four-wing saltbush A-16652	11	18	9.0	16
6	Sema	Plains bristlegrass A-9971	14	17	6.5	2
7	Orhy	Indian ricegrass 3763	6	33	11.5	16
8	Orhy	Indian ricegrass 4406	16	118	36.5	41
9	Orco	Blue ricegrass A-10696	43	27	8.0	3
10	Ster	Mandan ricegrass A-15538	1	11	5.5	2
11	Ledy	Green sprangletop A-14254	641	1	0.5	0
12	Muwr	Spike muhly A-8604	456	160	160.5	135
13	Tedr	Karoo grass A-14408	299	62	29.0	46
14	Dier	Fingergrass A-12616	141	0	0.0	0
15	Spcr	Sand dropseed A-16352	823	462	218.0	170
16	Spco	Spike dropseed A-14544	202	57	49.0	113
17	Spus	Creeping dropseed A-14399	438	115	46.5	75
18	Spai	Alkali sacaton A-13156	238	111	69.0	68
19	Erle	Lehmann lovegrass A-68	1102	0	0.0	0
20	Erle	Lehmann lovegrass A-14107-[illegible]	1806	29	1.0	0
21	Erle	Lehmann lovegrass A-14328	957	1	0	0
22	Erbi	Bicolor lovegrass A-14152	328	4	0	0
23	Erch	Boer lovegrass A-67	192	1	0	1
24	Agcr	Crested wheatgrass (Comm'l)	36	85	61.5	57

Table 24. Continued

Plot No.	Species	September seeded Common name and source	Date counted 8/20/64	 8/8/65	 7/1/66
1	Agcr	Crested wheatgrass (Comm'l)	46	25	65
2	Elju	Russian wildrye (Comm'l)	167	71.5	128
3	Agin	Intermediate wheatgrass A-12496	190	63.5	126
4	Agsi	Siberian wheatgrass (Comm'l)	283	41.5	81
5	Agcr	Pubescent wheatgrass (Luna)	263	94.5	167
6	Elci	Giant wildrye A-13036	5	9.5	17
7	Eula	Winterfat SS1-62	0	0	0
8	Eula	Winterfat A-16161	0	0	0
9	Orco	Blue ricegrass A-10696	40	1.5	11
10	Orhy	Indian ricegrass 4406	82	32.0	40
11	Orhy	Indian ricegrass 3763	17	11.5	8
12	Orhy	Indian ricegrass (Red Desert)	13	4.0	6
13	Stor	Mandan ricegrass A-15538	1	2.0	5
14	Sihy	Squirrel-tail (Springerville)	27	11.0	42
15	Agin	Intermediate wheatgrass (Amur)	109	32.5	62
16	Agtr	Pubescent wheatgrass 4302	121	54.0	91
17	Agsm	Western wheatgrass	56	31.5	78
18	Agin	Intermediate wheatgrass 2788-25	221	66.0	109
19	Sami	Burnet 2741	1	0	0
20	Atca	Four-wing saltbush 4348	8	2.5	11

Table 25. The number of plants per 100 square feet in a species adaptation nursery planted in July and September, 1964 near Fredonia, Arizona.

Plot No.	Species (Seeded early July)	Source	Date Counted 7/8/65	9/3/65	6/29/66
1	*Agropyron cristatum*	(Comm'l)	146	87.5	105
2	*Agropyron tricophorum*	(Luna)	38.5	48.5	66
3	*Bouteloua gracilis*	(Stock)	26	33.0	18
4	*B. gracilis*	A-12424	23	7.0	20
5	*B. curtipendula*	A-3603	20.5	42.5	31
6	*B. eriopoda*	A-3730	9.5	8.0	0
7	*Eragrostis lehmanniana*	A-14107	0	0.5	0
8	*E. bicolor*	A-1415	0	0.5	0
9	*E. curvula*	(Comm'l)	0	1.5	0
10	*Muhlenbergia porteri*	A-13273	0	1.0	0
11	*M. wrightii*	A-8604	0	0.5	1
12	*Sanquisorba major*	A-14173	3.5	3.5	0
13	*Tetrachne dregei*	A-14408	0	0	0
14	*Digitaria eriantha*	A-12616	0	0	0
15	*Leptochloa dubia*	A-12254	0	0	0
16	*Oryzopsis hymenoides*	A-12242	5.0	5.5	2
17	" "	A-14719	7.0	1.5	5
18	" "	A-16503	9.0	2.5	3
19	*Sporobolus airoides*	A-13156	3.5	3.5	4
20	*S. contractus*	A-14544	13.5	7.5	10
21	*S. cryptandrus*	A-16352	63.0	70.0	2
22	*S. usitatus*	A-14399	2	2.5	8
23	*S. flexuosus*	A-10117	2	1.0	2
24	*Andropogon ischaemum*	A-14207	30	36.5	5
25	*Atriplex canescens*	A-16652	100	7.5	7
26	*Sanquisorba minor*	A-14173	1.5	0.5	2

Table 25 Continued

Plot No.	Species (Seeded early September)	Source	Date counted 7/8/65	9/3/65	6/29/66
1	*Agropyron tricophorum*	(Topar)	15	15.5	23
2	*A. cristatum*	(Comm'l)	62.5	35.5	60
3	*Kangaroo Valley rye*		14	1	3
4	*A. intermedium*	A-12496	41.5	37	69
5	*A. intermedium*	(Amur)	36	31	46
6	" "	(Greenar)	54.5	31	51
7	*Eragrostis lehmanniana*	A-14107	0	0	0
8	*Agropyron tricophorm*	(Luna)	115.5	65	89
9	*A. sibericum*	P-27	26	42	45
10	*A. interme*	(Whitmar)	58	40.5	52
11	*A. smithii*	(Comm'l)	7	4	8
12	*Stiporyzopsis*	A-15539	0.5	1	0
13	*Festuca ovina*	(USFS)	15	0.5	0
14	*Elymus juncus*	(Comm'l)	66	50.5	88
15	*Elymus triticoides*	(Local)	39	41.5	2
16	*Oryzopsis hymenoides*	A-12242	17	4	1
17	" "	A-14719	30	8.5	3
18	" "	A-16503	28	16	1
19	*Bouteloua gracilis*	A-12424	0.5	0.5	1
20	*Sporobolus contractus*	A-14544	2	0.5	0
21	*S. cryptandrus*	A-16352	0	1	3
22	*Mendora scabra*	A-16807	0	0.5	0
23	*Purshia glabrata*	(USFS)	0	0	0
24	*Atriplex canescens*	A-16652	0	0.5	0
25	*Sanquisorba minor*	A-14173	10	1.5	0

Table 26. The species planted in the species observation plots at Fredonia, Arizona on July 9 and October 18, 1965. Values are plants per 100 square feet for the summer seeding.

Plot No.	Species (July seeded)	Source	Date counted	
			9/16/65	9/14/66
1	*Agropyron cristatum*	(Comm'l Neb. & Montana)	1.5	38
2	*A. desertorum*	(Nordan)	8	22
3	*A. trichophorum*	(Topar)	1	14
4	*A. trichophorum*	(Luna)	4.5	45
5	*A. intermedium*	A-12496	3	8
6	*A. intermedium*	(Greenar)	2.5	15
7	*A. smithii*	(Comm'l)	0.5	2
8	*A. sibericum*	A-10675	2.0	4
9	*A. sibericum*	(Comm'l. Idaho)	5.0	15
10	*Elymus juncus*	(Comm'l. Montana)	2.5	2
11	*Atriplex canescens*	A-16831	0	0
12	*Muhlenbergia porteri*	A-13272	0	0
13	*Sanguisorba minor*	A-14173	0	0
14	*Sporobolus contractus*	A-14544	0	1
15	*S. cryptandrus*	(Comm'l. Yuma)	0	0
16	*S. airoides*	(Wilcox)	0	0
17	*Andropogon ischaemum*	A-14207	3.0	0
18	*Leptochloa dubia*	A-14254	0	0
19	*Oryzopsis hymenoides*	(Mohave)	1.5	7
20	" "	(Holbrook)	0	19
21	" "	P-2575	1.0	11
22	" "	(Albuquerque)	0	19
23	" "	(Shiprock)	0	20
24	*Muhlenbergia wrightii*	(Cimarron)	0	0
25	*Tetrachne dregei*	A-14408	0	0
26	*Bouteloua curtipendula*	A-3603	4.5	0
27	*Eragrostis lehmanniana*	A-14107-108	0	0
28	*Bouteloua eriopoda*	A-3730	0	0
29	" "	(Naipai)	0.5	0
30	*B. gracilis*	(Captan)	0.5	0
31	" "	(Comm'l. Colorado)	0	0

Table 26 continued.

Plot No.	Species (October seeded)	Source	Date Counted 9/14/66
1	*Agropyron cristatum*	(Comm'l. Neb. & Montana)	42
2	*A. desertorum*	(Nordan)	40
3	*A. trichophorum*	(Topar)	34
4	*A. trichophorum*	(Luna)	53
5	*A. intermedium*	A-12496	22
6	*A. intermedium*	(Greenar)	28
7	*A. smithii*	(Comm'l.)	1
8	*A. sibericum*	A-10675	3
9	*A. sibericum*	(Comm'l. Idaho)	90
10	*Elymus juncus*	(Comm'l. Montana)	15
11	*Atriplex canescens*	A-16831	4
12	*Muhlenbergia porteri*	A-13273	0
13	*Sanguisorba minor*	A-14173	2
14	*Sporobolus contractus*	A-14544	0
15	*S. cryptandrus*	(Comm'l. Yuma)	0
16	*S. airoides*	(Wilcox)	0
17	*Andropogon ischaemum*	A-14207	0
18	*Leptochloa dubia*	A-14254	0
19	*Oryzopsis hymenoides*	(Mohave)	30
20	" "	(Holbrook)	6
21	" "	P-2575	22
22	" "	(Albuquerque)	12
23	" "	(Shiprock)	12
24	*Muhlenbergia wrightii*	(Cimarron)	0
25	*Tetrachne dregei*	A-14408	0
26	*Bouteloua curtipendula*	A-3603	0
27	*Eragrostis lehmanniana*	A-14107-108	0
28	*Bouteloua eriopoda*	A-3730	1
29	" "	(Naipai)	0
30	*B. gracilis*	(Captan)	1

Table 27. The species planted in the species observation plots at Fredonia, Arizona on July 9 and October, 1965. Values are plants per 100 square feet for the summer seeding.

Plot No.	Species	Source	Date counted 10/66
1	*Agropyron cristatum*	Comm'l.	1
2	*A. cristatum*	Comm'l.	1
3	*A. sibericum*	P-27	0
4	*A. trichophorum*	Luna	3
5	*A. trichophorum*	Topar	1
6	*A. intermedium*	Greenar	0
7	*A. intermedium*	12496	0
8	*Elymus juncus*	Comm'l.	0
9	*Stipa comata*		0
10	*Muhlenbergia wrightii*	Cimarron 8604	0
11	*Andropogon ischaemum*	Buckhead 14207	96*
12	*Sporobolus airoides*	Wilcox 920	0
13	*Panicum obtusum*	Pearse 11711	2
14	*Oryzopsis hymenoides*	14719 P-2575	0
15	" "	Albuquerque 12242	0
16	" "	Mohave 14718	0
17	" "	Shiprock 16590	0
18	" "	Holbrook 16503	0
19	*Bouteloua eriopoda*	A-3730	0

* Runoff water on this plot

inerme) and pubescent wheatgrass (*A. tricophorum*). These species, as shown in Figures 24 and 25, were planted in September 1964 and photographed in October 1966.

As previously indicated, the precipitation during the growing season at Fredonia was extremely light for good plant growth. Detailed weather records covering temperature, relative humidity, precipitation, wind speed, and evaporation from an evaporation pan were maintained during the summer growing season. This permitted the same type of comparison as was made at Congress and Pima on the effectiveness of the precipitation. Although the winter and spring (November through May) precipitation was

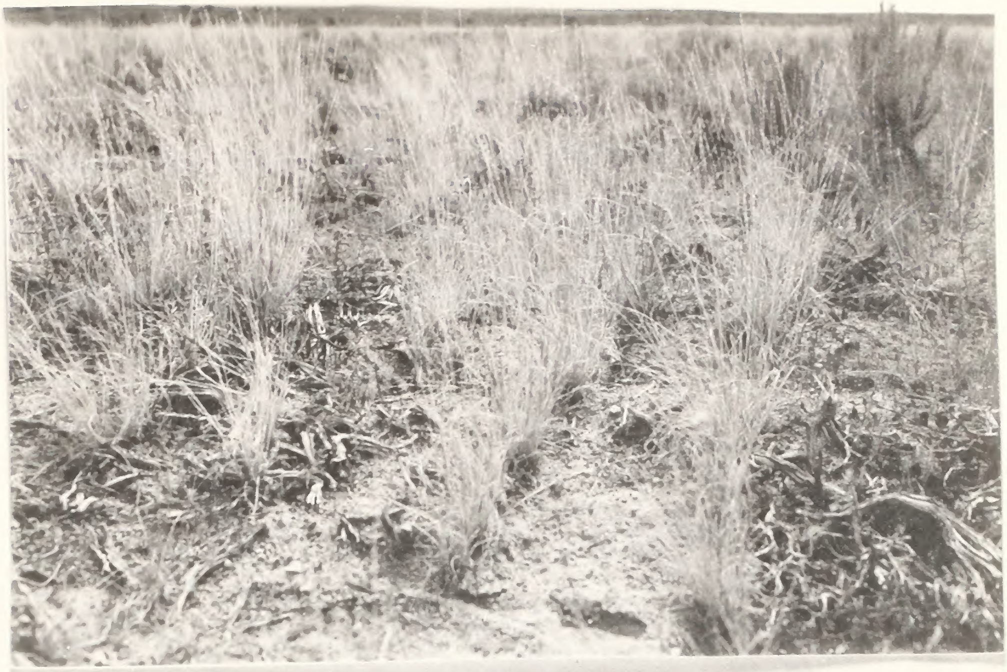


Figure 24 Agropyron inerme (Whitmar) seeded September 1964. Photographed October 1966.

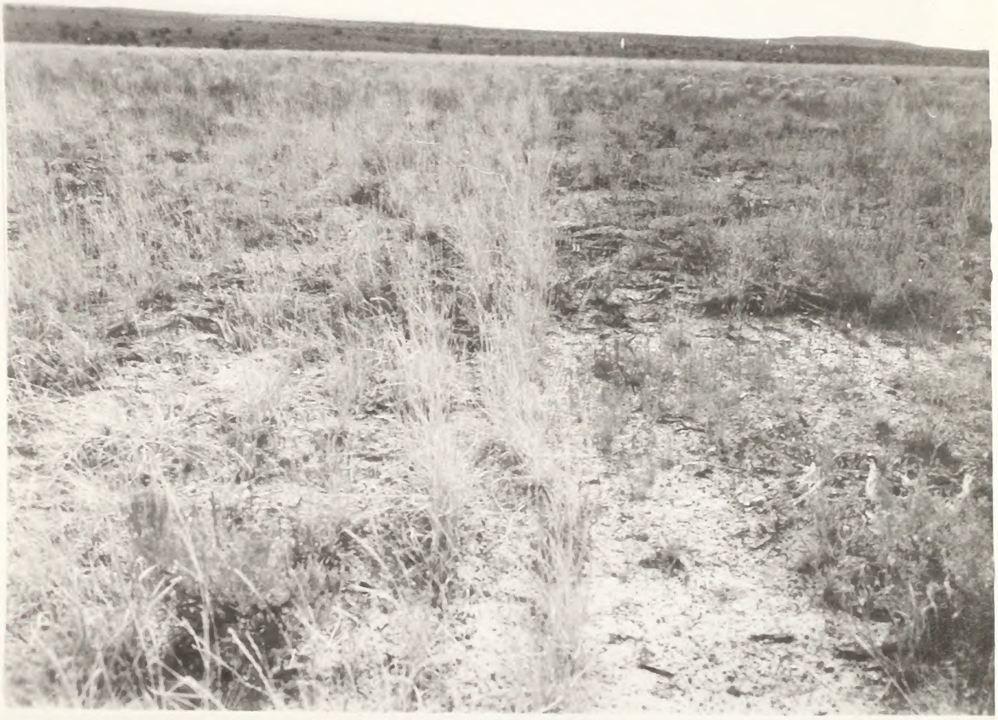


Figure 25 Agropyron tricophorum (Luna) on the left A. sibericum on the right. Seeded in September and photographed October 1966.

good, 160.8 mm (6.33 inches), which provided moisture for growth of the established stands, the summer (July 1 to October 26) moisture was only 39.9 mm (1.57 inches). There was only one rainfall on September 18 of 10.2 mm (.4 inch) which provided some effective moisture of 1.2 mm.

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Evaluation of seedbeds,
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